PARK SCIENCE

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An Integrated Approach to Marine and Terrestrial Research in Virgin Islands National Park and Biosphere Reserve

By Caroline S. Rogers

Virgin Islands NP comprises a little over half (2,816 ha) of the island of St. John (U.S. Virgin Islands) in the Caribbean Sea. Established in 1956, the park was expanded in 1962 to encompass 2,287 ha of the surrounding waters. St. John's topography is rugged, with deep valleys and hills that rise abruptly from the coastline. Over 80 percent of the slopes exceed 30 percent. The highest point on the island is 387 m above sea level. St. John has no permanent streams or rivers, but erosion channels ("guts") form narrow valleys through which intermittent streams discharge into the sea. The island supports dry evergreen and moist forests and is surrounded by coral reefs, seagrass beds, and clear waters.

Virgin Islands NP was designated an international biosphere reserve (BR) in 1976 and is one of the few BRs that has both marine and terrestrial resources. In 1987, the Virgin Islands Biosphere Reserve Center, which houses the park's Division of Research and Resource Management, was completed. UNESCO's Action Plan for BRs echoes NPS policy in calling for compilation of baseline data on natural resources and long-term monitoring of protected ecosystems as reference points for comparison with less protected environments. More detailed information on natural variations in ecosystem structure and function will permit more effective resource management and a better understanding of the effects of human activities on the environment.

In this issue of ***Park Science*** we present a series of articles on the research program in Virgin Islands NP which focuses on long-term assessment of marine and terrestrial ecosystems, particularly coral reefs and forests of St. John. Many of the ongoing studies have evolved from work carred out from 1984-1989 by NPS and other members of the Virgin Islands Resource Management Cooperative (VIRMC). The approach has been to encourage comprehensive and complementary research on the island's natural resources, especially within critical watersheds (e.g., Lameshur and Cinnamon Bays).

Most of these projects represent several years of monitoring. For example, Dr. Peter Weaver, with the

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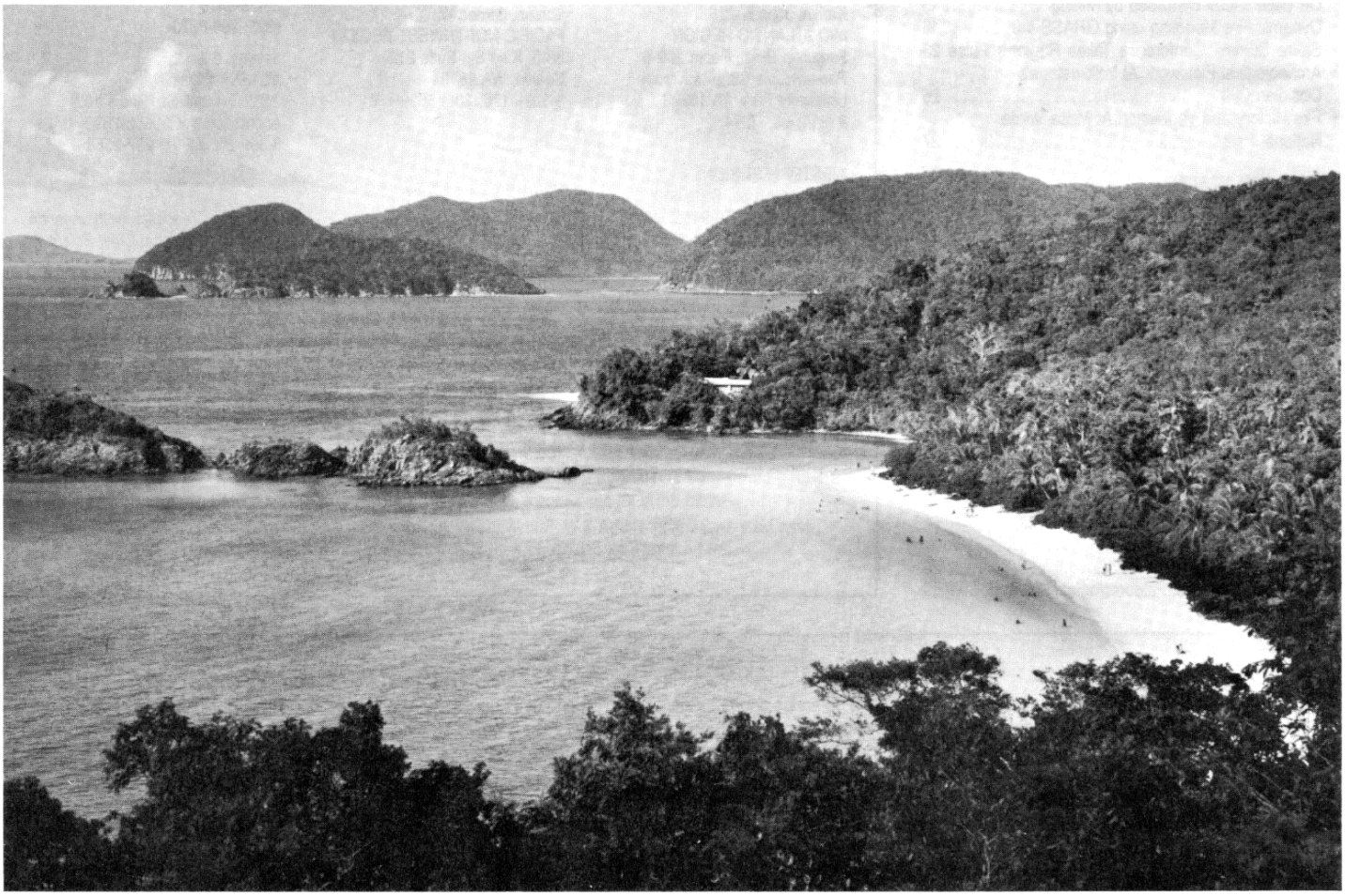

Trunk Bay *in Virgin Islands NP and Biosphere Reserve. (Photo by Sharon K. Sneddon).*

PARK SCIENCE

NATIONAL PARK SERVICE

SPRING 1992

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management

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DEPARTMENTS

MISCELLANEOUS

editorial

Evidence of the strong chord struck by the Vail conference celebrating the National Park Service's 75th anniversary is contained on page 14 of this issue. The monumental job of assessing "who we are and what for us is true" (to quote a hymn) that started in October 1991 in Vail, Colorado, is continuing throughout the Service. Rick Smith's observations succinctly state the feelings of others who contacted the editor, while Loren Fraser's letter acknowledges the bases for these feelings and describes the steps being undertaken at the directorate level to involve the entire Service in addressing them. It is just such lively and open expressions that keep hope very much alive, and which justify pride in our present as well as our past.

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In the Next Issue

The Summer issue of ***Park Science*** will feature Paleontological Research and Resource Management in the National Park System. Nearly 70 NPS areas with significant fossil resources have been identified ... some are classic fossil collecting localities and continue to support active paleontologic research.

The history of life on earth is well represented, ranging from Precambrian stromatolites of Glacier NP to an Ice age mammoth in Arches NP. Dinosaur, Fossil Butte, John Day, and Petrified Forest employ fulltime paleontologists to coordinate fossil research.

The management of paleontological resources on federal lands is becoming a critical issue, and coverage of this subject area is overdue. The cooperation between professional paleontologists and park staff will be apparent in the Summer issue.

In addition, the Francis Singer article on Yellowstone northern range ungulates will (we hope) be ready in time for the Summer issue. Also scheduled are 2 visitor studies that we were unable to fit into this issue: a Visitor Use Reporting study at Acadia NP (by Kenneth Hornback and Robert Manning), and a study by Manning and Margaret Smith on evolving significance to visitors of Roosevelt Campobello International Park.

Impacts of Natural and Human Disturbance On Forests of St. John, U.S. Virgin Islands

By Anne E. Reilly

For years, researchers have been exploring changes in successional patterns and processes in plant community development following disturbance events (Pickett and White 1985). Understanding the disturbance effects on vegetation is important for land managers involved with protection and acquisition of parks and reserves. Effects of both human and natural influences often promote different responses in vegetation.

Human Disturbance

The history of the island of St. John, U.S.V.I., is similar to that of many other islands in the Caribbean. Originally the island was completely forested, but as numerous groups of Ameri-Indians and Europeans settled here, the island landscape began to change. Initially, the impact probably was minor, since many of the early arrivals existed by hunting and gathering. As other groups arrived, some land was developed for subsistence agriculture. Eventually, with the arrival of Europeans, a large scale plantation economy emerged. It is during this period that the greatest changes in the island's forests most likely took place.

Approximately 90 percent of the forests were removed during the 1700s and 1800s, when the sugarcane industry was at its peak (Tyson 1987). A combination of factors eventually led to the demise of this exploitive economy; emancipation of the slaves, declining soil fertility, increasing erosion, and the low price of sugar. Following this period of intense environmental destruction, the land was abandoned. The few individuals who remained practiced subsistence agriculture; thus, the forests began to recover.

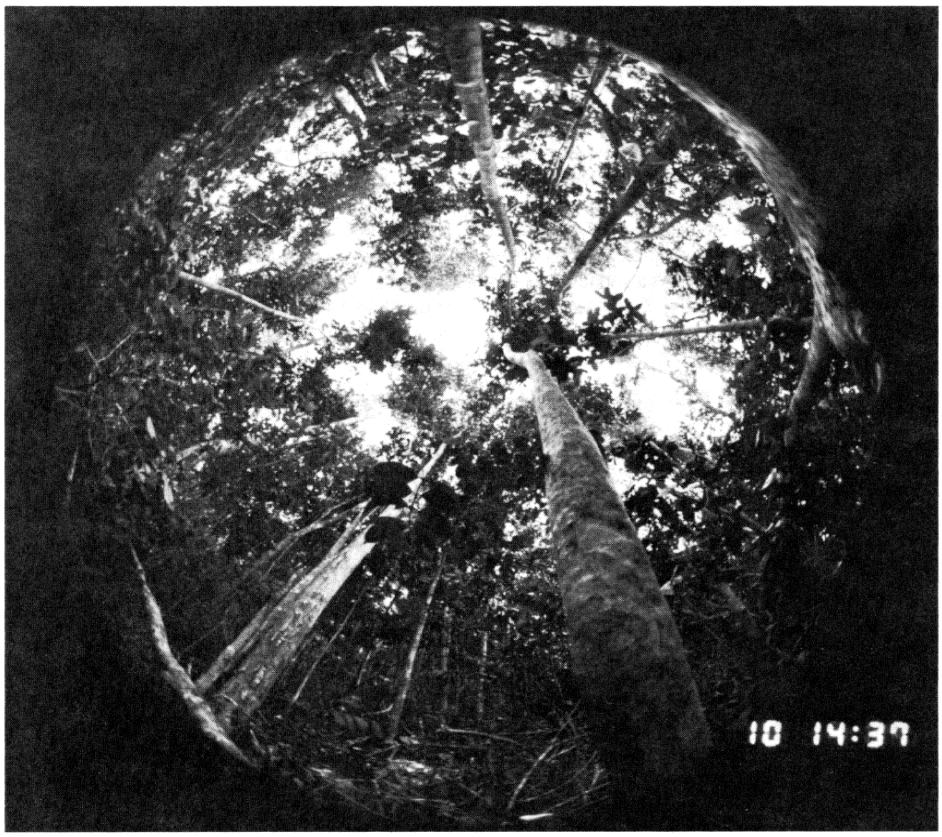
The Virgin Islands were purchased by the United States from Denmark in 1917, and in 1956 approximately 50 percent of the land was designated as a national park. Protection of more than half the island provided a unique research opportunity (Reilly et al 1990).

In 1985-86, the St. John Forest Dynamics Project was initiated with NPS support. Over the years other institutions also have been involved – the Yale School of Forestry, the New York Botanical Garden, The University of the Virgin Islands, and U/GA's Institute of Ecology. The intent of the research program was to monitor forest regeneration in relation to past land use history as part of the Virgin Island Resource Management Cooperative's (VIRMC) islandwide study of three critical watershed systems. This is the sixth year of the long-term monitoring program.

Natural Disturbance

Humans have significantly modified this landscape. Some researchers believe the current vegetation is much drier than what originally was present, due to the long lasting effects of the plantation economy (Woodbury and Weaver 1987). However, natural forces also have played a role in the disturbance regime, hurricanes being the most severe form. It is estimated that once every 70 years a severe hurricane will pass over an island (Neumann et al 1978). The most recent such, affecting St. John, was Hugo in the fall of 1989 (Reilly 1991).

Despite the damage they pack, hurricanes appear to increase species diversity (Weaver 1989). They provide a myriad of habitats, which can support many different species due to variety of light and moisture environments. Empirical evidence from long-term studies of hurricane influenced forests (Crow 1980, Weaver 1986) indicates specific patterns of forest recovery following hurricanes in terms of species richness, tree density, and basal area.



Looking at the forest canopy *through the eye of a hemispherical lens. Image analysis software used in conjunction with the photograph will enable quantification of incoming light.*

Forest Dynamics Project

The goal of current research is to investigate the role of disturbance, both natural and human induced (i.e. past land use history) in three forest plots on the island. Disturbance plays a key role in determining the species composition and physiognomy at each site. The degree of disturbance in a particular forest area may promote different responses in the vegetation.

Three permanent forest plots have been established within the boundaries of Virgin Islands NP to investigate the impact of these disturbances. The plots are representative of the surrounding forests, can be separated along a moisture gradient, and are in three different watersheds. Using the local names and the vegetation classifications of Woodbury and Weaver (1987) the areas can be described as: Bordeaux, upland moist forest, 1.0 ha in size, located on the Reef Bay watershed; L'Esperance, gallery moist forest, 1.0 ha, located in Fish Bay watershed; and Hawksnest, dry evergreen woodland, 0.5 ha, in the Hawksnest Bay watershed. Within these plots, all stems 5 cm or greater have been identified to the species level, measured to the nearest mm, and mapped to the nearest 0.5 meter. In addition, 250, 1x1 sub-plots have been established to examine seedling regeneration in the forest plots.

To date, well over 6,000 stems have been examined for rates of growth and mortality, levels of recruitment, hurricane damage assessment, and other factors. In addition, several hundred seedling plots have been studied to assess changes in species composition and percent cover over time, and – fortuitously for this study – changes due to hurricane damage.

The forest at Bordeaux is approximately 100 years old, based on the plantation's time of abandonment shown in tax records (G.Tyson and S.Edwards, pers. com.). This 1-ha site contains 63 species, represented in 34 families (Table 1). This plot is dominated by native species, of which some of the most common are *Guapira fragrans* (black mampoo), *Pimenta racemosa* (bay rum tree), *Inga fagifolia* (amarat), *Ardisia obovata* (breakbill), and *Byrsonima coriacea* (hogberry).

The L'Experance plot supports trees that are approximately 80 years old (G.Tyson and S.Edwards, pers. com.) and is home to 56 species in 29 families (Table 1). This 1-ha site also is dominated by native species. Most commonly encountered are *Ardisia obovata, Guapira fragrans, Andira inermis* (pig turd), *Ocotea coriacea* (pepper cillament), and *Chrysophyllum pauciflorum* (palmat).

Hurricane Impacts

The diameter and height of the stems in the forest, the species composition, and the topography of the landscape as well as the direction of the winds, all affect the response of the forest to a hurricane. Each stem was ranked into a damage class category that

Continued on page 4

Forest Service Research in Virgin Islands National Park

By Peter Weaver

In cooperation with the University of Puerto Rico, Rio Piedras, the U.S. Forest Service began research in the Virgin Islands NP in 1982 with a survey of the park's vegetation (Woodbury and Weaver 1987). All natural and naturalized species of herbs, shrubs, and trees found on St. John and Hassel Islands were identified, and a herbarium was created in the park. A list of species with their relative abundances by vegetation type also was prepared. The flora of St. John contained at least 116 families and 792 species; 66 families and 297 species were enumerated for Hassel Island; 18 species were designated as rare or endangered, and 6 of these appeared to be new to science. The medicinal uses of many species also were described.

The main vegetation types on both islands were classified and mapped. More than 60 percent of St. John has dry evergreen formations (Table 1). The moist forest formations occupy about 16 percent of the island. In contrast, mangrove, salt flat, and lagoon areas are limited in extent. The remainder of the park is covered with secondary vegetation, pasture, and urban areas. Hassel Island, only about 54.2 ha, is in Charlotte Amalie harbor, and contains mangrove, moist basin forest, dry evergreen thicket, thorn and cactus, coastal hedge/rock pavement, and secondary scrub comprised of *Acacia, Croton*, and *Leucaena*.

Impacts on Virgin Islands Forests *(continued from page 3)*

Table 1. *Summary of forest characteristics at three permanent sites.*

Study Site	*Bordeaux*	*L'Esperance*	*Hawksnest*
Area	*1 hectare*	*1 hectare*	*0.5 hectare*
Watershed	*Reef Bay*	*Fish Bay*	*Hawksnest Bay*
Approximate Age	*100 years*	*80 years*	*45 years*
Life Zone	*Upland Moist Forest*	*Gallery Moist Forest*	*Dry Evergreen Woodland*
Species and Family Richness	*63 species* *34 families*	*56 species* *29 families*	*51 species* *27 families*
Dominant Species	*Guapira fragrans* *Pimenta racemosa* *Inga fagifolia* *Ardisia obovata* *Byrsonima coriacea*	*Ardisia obovata* *Guapira fragrans* *Andira inermis* *Ocotea coriacea* *Chrysophyllum pauciflorum*	*Melicoccus bijugatus* *Guapira fragrans* *Bursera simaruba* *Ocotea coriacea* *Eugenia monticola*

indicated whether there was loss of a primary or secondary branch or whether the stem was snapped off or tipped over. Results from Hugo suggest that taller and larger diameter trees usually were more severely damaged than shorter, smaller diameter trees; that forests on slopes facing the winds were more damaged than leeward forests, and that low elevations received more damage than higher elevations within each site (Reilly 1991).

Current work is focusing on the recovery of forests to hurricane damage. One method being employed to document these changes is the use of hemispherical photography. A fish-eye lens is used to photograph an upward looking image (i.e. the forest canopy) in a 180-degree field of view. This image is processed with an image analysis software package, to estimate light that is reaching the forest floor and thereby facilitating growth. Six weeks following Hurricane Hugo the canopy above all seedling plots was photographed. In fall 1991, another set was taken in the same locations. Results of this work should indicate the resilience of these systems to natural disturbance.

Changes in percent cover and species composition triggered by the recent hurricane also are being investigated. Data were collected in the spring before Hugo, and then again in the spring of 1991. Preliminary analysis indicates changes in both species composition and percent cover (Reilly unpub. data).

Future work will provide further insight into the patterns and processes of these tropical forest ecosystems. Of specific interest are canopy-seedling interactions, species distributions as influenced by topographic position, mortality and recruitment rates of native and exotic tree species, and changes in forest composition through time. Understanding the responses of vegetation to the impacts of natural and human disturbance – the sensitivity or the resistance of these systems – should greatly aid management of these limited natural resources.

Reilly is a doctoral student at U/GA's Institute of Ecology. She has been investigating tropical plant community ecology on St. John for the last 6 years.

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Long-term Ecological Studies

Cinnamon Bay encompasses about 1.32 km^2 in the north-central park of St. John (Fig. 1) and receives about 1300 mm/yr of rainfall. The watershed ranges in elevation from sea level to about 330m in the southeast, only slightly more than 1 km from the shore. The rough topography is characterized by steep slopes and numerous ravines with streambeds devoid of water except after heavy rains. A pronounced soil moisture gradient exists at all elevations from well-drained ridges and upper slopes to the moister lower slopes and ravines.

The response of ecosystems to biotic influences and random events is best assessed through long-term sampling on representative permanent plots. In 1983, the U.S.F.S. initiated the island's first long-term terrestrial research in the Cinnamon Bay watershed. Sixteen permanent 50 x 10 m plots were stratified in groups of three by topographic positions (ridge, slope, and ravine), at elevations of about 60, 120, 180, 210, and 240 m, with the last plot located near the summit. Objectives of the study were to determine species composition, structural characteristics, species-site relationships, and growth rates in the forest (Weaver and Chinea-Rivera 1987). Heights, diameters at breast height, and crown classes were recorded for all trees over 4 cm. Sixty-nine tree species were identified from the 2,698 stems sampled on all plots.

The 10 most common species accounted for 65 percent of the stems and nearly half of the basal area. *Maytenus elliptica* had the greatest density, averaging 428 stems/ha. In contrast, *Torrubia fragrans* averaged 4.9 m^2/ha and occurred on 15 plots, giving it the highest basal area and frequency of occurrence, respectively, of any species in the watershed.

Stem density in the Cinnamon Bay watershed is high, with the number of trees averaging 3,370/ha for all of the plots. The highest tree density is found on the summit and the lowest in the ravines. The mean height and diameter for all tallied trees is about 8 m and 9 cm, respectively. Basal area averages about 30 m^2/ha. Mean heights and diameters for all stems vary little by topography; however, when only the largest trees in each plot are considered, tree heights and diameters are greatest in the ravines and smallest on the ridges.

A statistical approach (Reciprocal Averaging ordination) was used to detect elevational trends and topographic preferences for 35 species that occurred at least three times in the data set. The major groupings were: ridge species from low to high elevation; cosmopolitan species; ravine species from low to high elevation; slope species; and, transition species from valley to ridges at low elevations. Site information for tree species, especially those considered to be rare or endangered, is useful for locating them in the wild and for vegetative restoration projects.

Tree Growth and Forest Dynamics

All of the Cinnamon Bay plots were re-measured in 1988 (Weaver 1990). At this time, 206 new trees were recorded (representing ingrowth, or stems growing into the minimum diameter class) whereas 161 stems died. This flux in tree numbers yielded an average increase of 12 stems/ha/yr during the 5 year period of measurement.

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Smithsonian Institution's Permanent Monitoring Plot: Research Opportunities in a Rare, Semi-Evergreen Dry Woodland

By Francisco Dallmeier and Gary Ray

In March, 1990, the Smithsonian Institution's Man and the Biosphere Biological Diversity Program (SI/MAB), with NPS cooperation, established a forest monitoring plot 1-ha in size, within the boundaries of the Virgin Islands NP. The permanent plot encompasses a stand of dry forest, an ecosystem which is underrepresented in the Smithsonian Institution's international network of forest monitoring plots.

Dr. Francisco Dallmeier, Director of the Smithsonian's SI/MAB Biological Diversity Program, and Gary Ray, a graduate student from U/WI-Madison, initiated the project. The interest in St. John's dry forest is based on its status as a minimally disturbed ecosystem protected by a national park and located within a biosphere reserve, which can serve as a reference study site for comparable ecosystems elsewhere in the Caribbean.

Among the objectives of the SI/MAB program are the establishment of sampling protocols so that widely differing sites may be compared temporally and spatially, and to enhance the professional training capabilities of the host-country. The biosphere reserve on St. John exhibits two elements, location and management, which provide an excellent case study for the Caribbean. Information gathered from the study plots is intended as a standard for evaluating future ecological changes against a matrix of human-altered ecosystems.

Since the Caribbean's dry forests have largely been eliminated, and the remaining stands degraded, forest relicts under study bear significant conservation value, both regionally and globally. Information on the composition and structure of St. John's dry forests can be used in many Caribbean developing countries where degraded forests need to be managed and restored.

Dr. Dallmeier is with the Smithsonian Institution; Ray is a graduate research assistant at U/WI-Madison.

Forest Service Research in the Virgin Islands NP *(Continued from page 4)*

Mean annual diameter growth for the 2,538 trees that survived was 0.07 cm/yr. Differences were apparent by crown class with dominant trees averaging 0.10 cm/yr, codominant and intermediate trees 0.08 cm/yr, and suppressed trees 0.06 cm/yr. Basal area increment for all plots averaged 0.26 m^2/ha/yr. Only one species, *Rauvolfia nitida*, disappeared from the plots, and no new species were recorded.

Hurricane Assessment and Productivity

On Sept. 18, 1989, Hurricane Hugo passed near St. John, doing considerable damage to the island's forests. In July 1990, all trees in the Cinnamon Bay plots were classified according to damage: uprooted, snapped, or little disturbed. In April 1991, all tags that were damaged or removed by the hurricane were replaced.

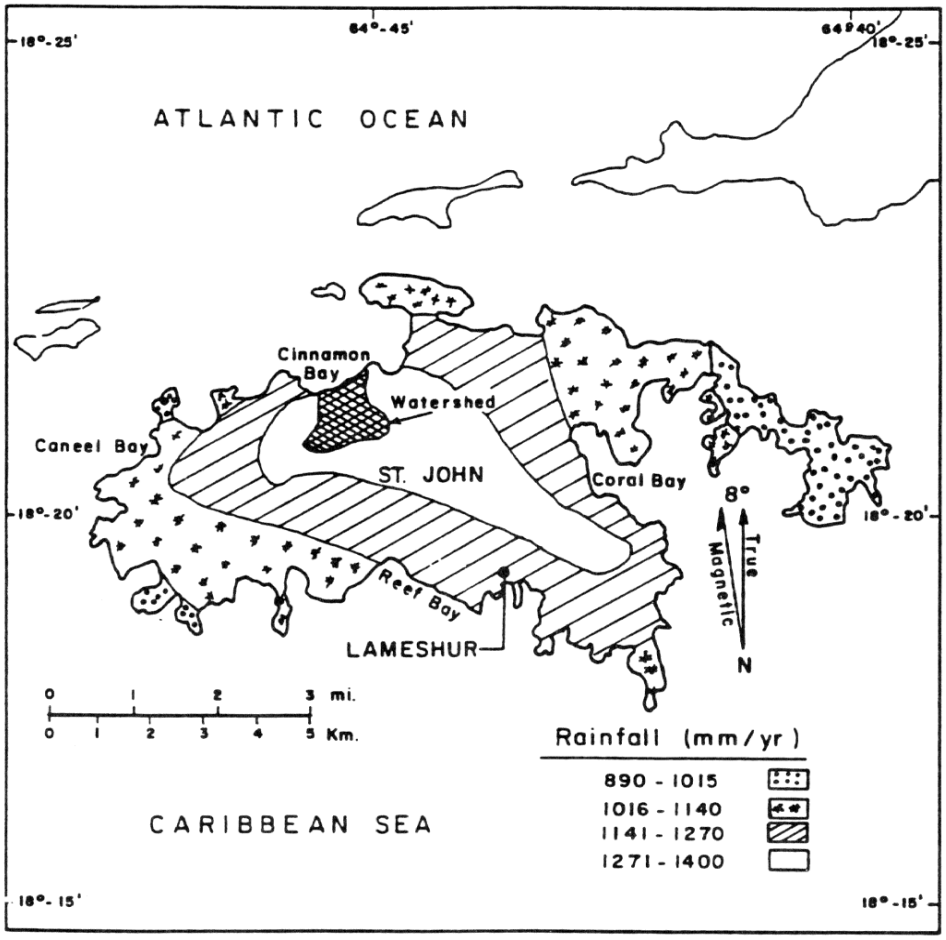

Figure 1. *St. John Island and the Cinnamon Bay watershed. Rainfall isoyets are also indicated.*

In May 1991, seven trees were harvested from approved locations, and leaves, branches, and trunks were oven-dried and weighed separately to yield biomass estimates. Based on data from these trees and 13 trees sampled in the wet limestone forests of north-central Puerto Rico, common equations were developed to predict leaf and woody biomass from stem dimensions (total tree height and diameter). These equations are currently being used in conjunction with the 1983 and 1988 plot measurements to determine biomass accumulation on the 16 plots, and to asssess biomass losses attributable to Hurricane Hugo.

Table 1. *Vegetation Types on St. John*

• Dry evergreen formations	
– Woodland	33.4%
– Thicket	21.5%
– Thorn and cactus	6.3%
– Coastal hedge/rock pavement	2.1%
• Moist forest formations	
– Upland forest	8.9%
– Gallery forest	3.9%
– Basin forest	3.6%
• Mangrove, salt flat and lagoon areas	2.3%
• Secondary vegetation	13.4%
• Pasture	2.0%
• Urban areas	2.6%
TOTAL	100.0%

Studies of litterfall, loose litter, and herbivory were initiated in February 1992. Data from these studies will be analyzed along with biomass accumulation rates to estimate the productivity of the Cinnamon Bay forest. Monitoring of all permanent plots will occur again in 1993. The 10-year record should provide reliable estimates of incipient changes in forest composition caused by Hurricane Hugo.

Dr. Weaver is with the Institute of Tropical Forestry in Puerto Rico.

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Restoring the Degraded Dry Forests of Virgin Islands NP

By Becky J. Brown, Gary J. Ray, and Tamra C. Mendelson

Virgin Islands NP, located on the 48 km2 island of St. John in the U.S. Virgin Islands and covering 56 percent of the island, consists of land that has been severely degraded by previous cultivation and livestock grazing. None of the original forest survives; however, a mosaic of secondary forest in various stages of recovery presently occupies almost all of the park. The native tropical dry forest plant community once covered most of the Caribbean islands, including most of St. John. Parts of St. John's natural areas are now inhabited by weedy and exotic species that deprive the land of its previous natural diversity.

Tropical dry forests were once a widespread and important vegetation type on Caribbean islands. While there are few undisturbed dry forests remaining to serve as models for our project, we do know that the typical tropical dry forest community consists of about 40-50 tree species per hectare, and is characterized by a relatively large number of rare and endemic species. Tropical dry forests occur in regions of low rainfall. Rainfall on St. John ranges from approximately 800 to 1500 mm/year and is highly sporadic, without well-defined wet or dry seasons (Fig. 1). Hurricanes in the region have infrequent, but severe impacts on the forest community.

The native plants of the tropical dry forest have developed strategies to deal with a stressful environment. They produce fruit primarily when environmental conditions are favorable, and growth is generally slow. Very little is known about the regenerative process in these forests, and prior to our study almost nothing was known about how to restore dry forest on degraded sites.

The loss of pristine forest on St. John prompted us to propose an ecological restoration of dry forest on one of the most degraded sites in the park. Initiated in 1988, the project is funded by the U.S. Man and the Biosphere Program (MAB), with additional support from the NPS. The major objectives of this project are to better understand the dynamics of tropical dry forest and to develop techniques for restoring the biodiversity of degraded dry forest habitat.

Mary Point, a peninsula on the north side of St. John, is the site of our restoration efforts. Historical records and aerial photographs indicate that the south-facing slope of Mary Point was heavily grazed for nearly 200 years, before the park was established. Forest recovery since then has been extremely slow. In 1988, about 30 years after the cattle and goats were removed, the area remains a tangle of thorny vines and weedy pioneer trees (Fig. 2). Hurricane Hugo devastated the vegetation of Mary Point in September 1989 and further retarded the recovery process.

A seedling inventory conducted in 1990 documented that although seedling densities were as high as 53 seedlings per square meter, only 6 tree species were represented. More than 98% were *Leucaena leucocephala*, a weedy, exotic tree species. These data show a species-poor seedling community at Mary Point, and suggest that active management may be required to restore the biological diversity of this forest community.

Table 1. *Regeneration characteristics of ten target species in tropical dry forest restoration project at Virgin Islands National Park.*

Species	Dispersal Agent	Germination Rate (%)	Vegetative Propagation (% Rooted)
Bursera simaruba	Bird	59	10
Capparis cynophallophora	Bird	83	0
Coccoloba microstachya	Bird	75	67
Guaiacum officinale	Bird	92	0
Guapira fragrans	Bird	91	17
Guettarda parviflora	Bird (?)	47*	8.7
Pisonia subcordata	Mammal (?)	87	0
Plumeria alba	Wind	96	22
Sabinea florida	Autochory	99	12
Tabebuia heterophylla	Wind	96	36

**Data expressed as percentage of fruits germinated. Multiple embryos per fruit increases germination success to 81 seedlings per 100 fruit planted.*

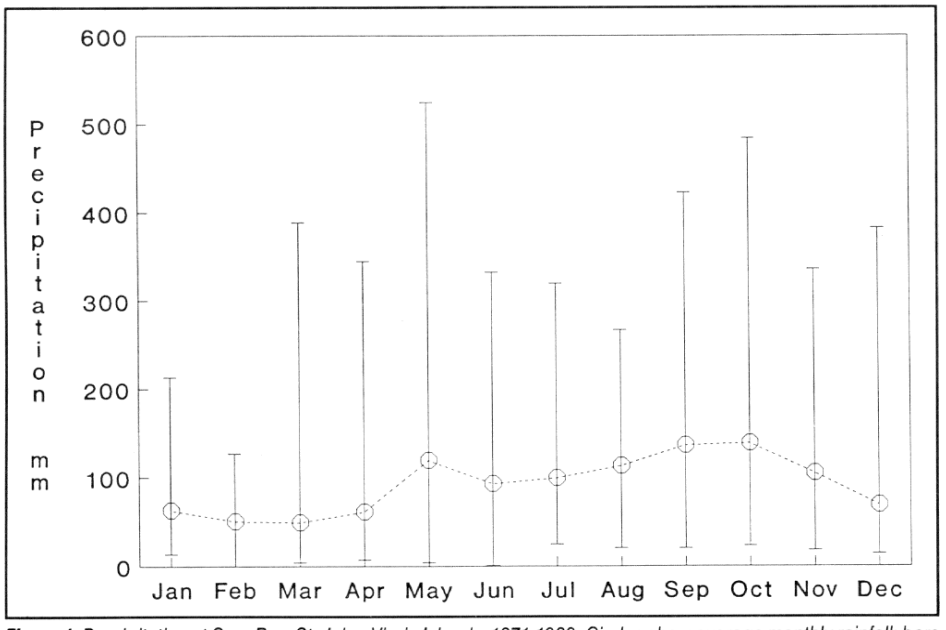

Figure 1. *Precipitation at Cruz Bay, St. John, Virgin Islands, 1871-1989. Circles show average monthly rainfall; bars indicate ranges.*

Testing Restoration Techniques

From the more than 100 tree species in the mature dry forest on the island, we selected ten target species for our initial restoration work (Table 1). These include both deciduous and evergreen species from the canopy and the understory strata.

Our goal at Mary Point is to enrich the diversity of the regenerating forest and, if possible, to hasten the recovery process. To reach this goal, we are first trying to determine which regenerative stage is limiting forest recovery. For example, rapid recovery of the forest on severely degraded sites may be inhibited by a shortage of seeds of dry forest species. Such a paucity of seeds would be expected after a long period of livestock grazing. If a lack of seeds is the primary factor limiting forest recovery, then importing seeds to the site may expedite the regenerative process. We are testing this hypothesis by broadcasting seeds of the 10 target species into experimental plots and monitoring germination and seedling survival. In 1990 we introduced 10,800 seeds of 6 species, and by June of 1992, we will have introduced a total of 14,000 additional seeds of 10 species. So far, the germination rates in the field have been quite low. In the shadehouse under more favorable conditions, germination rates on the same species are high (Table 1). The low germination in the field probably reflects unpredictable rainfall patterns, combined with the fact that seeds of many species lose viability quickly after dispersal. Our results thus far suggest that simply importing seeds to Mary Point may not be an effective means for accelerating forest regeneration.

We are also transplanting shadehouse-grown plants (Fig. 3) into the field, in order to test the idea that forest recovery can be accelerated by bypassing the germination and seedling establishment stage. We are field testing plants grown both from seed and from vegetatively propagated stem cuttings. We are growing these plants in shaded and unshaded plots to compare the feasibility of two restoration techniques: (1) planting cleared areas, versus (2) underplanting weedy and exotic species with natives. We are also testing the usefulness of Terrasorb, a soil moisture enhancing agent, in promoting seedling survival and growth. In

1990 we introduced 1152 seedlings of six species into field plots. We introduced 1000 additional seedlings and stem cuttings of 9 species in 1991. After 9 months we will estimate growth and biomass increment of surviving plants. This experiment will give us detailed information about growth requirements of each of the 10 target species.

Our shadehouse tests show that some, but not all, of our target species can be propagated vegetatively from stem cuttings (Table 1). The relative success of transplanted seedlings and cuttings in the field is yet to be determined. If results show high survival rates for cuttings, then vegetative propagation may prove to be an effective method for restoring species for which seed collection and germination are difficult.

Dry Forest Dynamics

Tied to our restoration experiments are ongoing field observations and measurements in secondary dry forests on St. John. Here the focus is on documenting the dynamics of the dry forest community. We are tracking the flowering and fruiting phenology of a total of 300 trees of 15 species. It appears that flowering and fruiting success are closely tied to weather conditions and vary greatly from year to year. Species such as *Pisonia subcordata* produce fruit during spring or early summer when rainfall is likely. Flowering in other species, such as *Sabinea florida*, may be triggered anytime of the year by rainfall after a long drought.

In 1988 we established 11 permanently marked 10 m X 50 m plots at 5 sites on the island. In these plots all mature trees more than 4 cm in diameter were tagged, and subplots were established for monitoring the growth of saplings and tree seedlings. These long-term plots will be monitored to assess naturally-occurring changes in species composition and stand structure.

A few hundred donkeys roam freely throughout the park. Although plans for management of the donkey population are being developed by the NPS staff, currently the donkeys present a serious threat to native vegetation in the park, particularly in the drier habitats. Donkeys show preferences in their choice of forage, and it appears that some native plants are much more vulnerable to donkeys than are others. Our experience indicates that *Bursera simaruba* and *Pisonia subcordata*, two important dry forest tree species, are particularly susceptible to donkey damage. Through their selective feeding, over time, donkeys can seriously alter the composition of the dry forest. Donkeys may in fact be an important factor inhibiting the recovery of the native vegetation at Mary Point. A 10 m X 50 m exclosure established as a part of our restoration project will help to document the long term effects of donkeys on the dry forest vegetation.

Management Implications

Our research is currently in an experimental phase. Results of our field investigations, scheduled for completion in 1992, will provide the ecological information needed to carry out a large-scale forest restoration at Mary Point. Management recommendations based on our research must be adapted to local biophysical and socioeconomic conditions. However, because of similar climate, soils, topography and land use histories on the drier islands of the Caribbean, the basic ecological information from our research should transfer readily for use in designing reforestation projects on other degraded dry sites.

Brown is Assoc. Prof. of Forestry and Environmental Studies at U/WI, Madison 53706; Ray is a graduate Research Assistant in the Institute for Environmental Studies, U/WI-Madison; Mendelson is field assistant and a recent graduate of U/W-Madison.

Figure 3. *Shadehouse-grown plants are transplanted into the field, bypassing the germination and seedling establishment stage.*

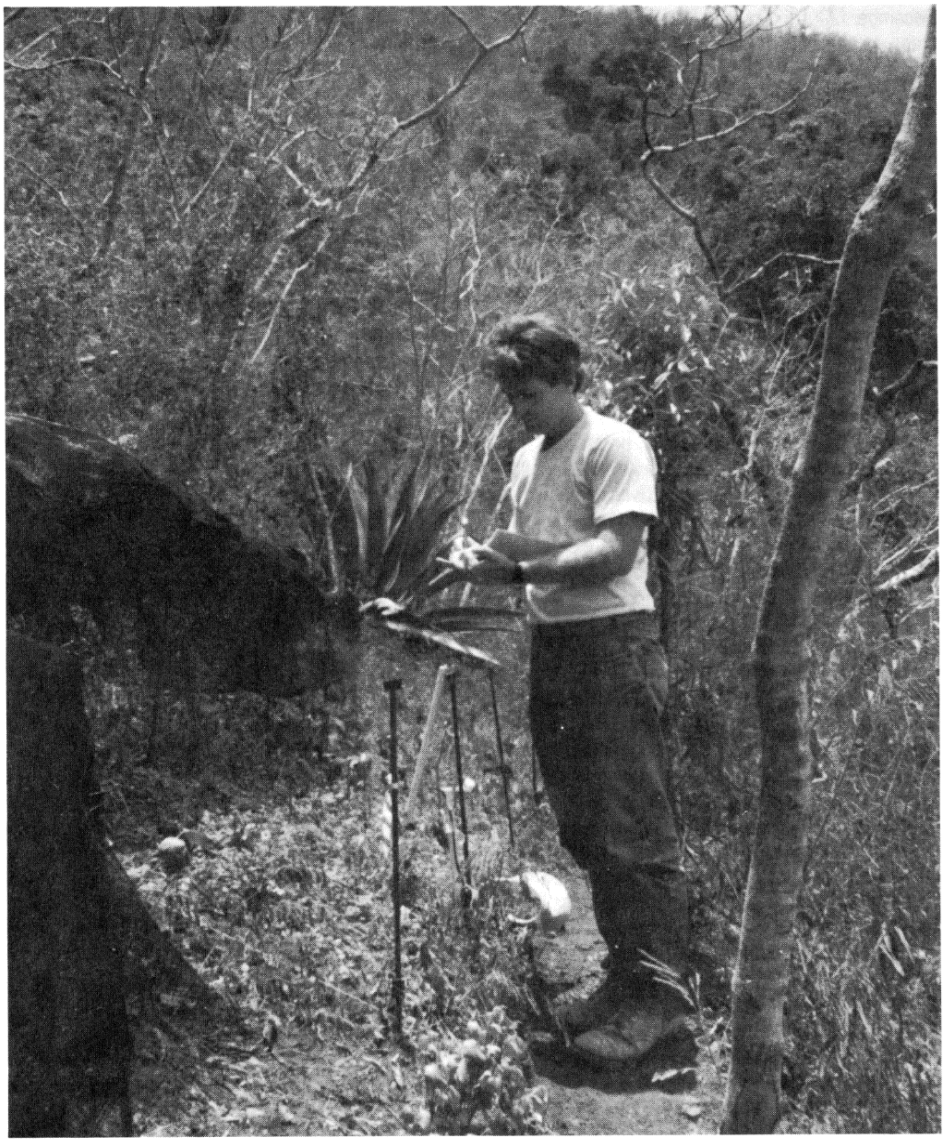

Figure 2. *Gary Ray, assessing seedling performance in a weedy, abandoned pasture at Mary Point, the site of the ecological restoration project.*

Effects of Hurricane Hugo on a Coral Reef in St. John

By Caroline Rogers

In 1988, the National Park Service initiated a long-term coral reef assessment program for Virgin Islands NP. A primary objective was to establish permanent long-term sites on coral reefs around the island. In January 1989, we established five 20 m transects on the coral reef that fringes Yawzi Point, the point which separates Little and Great Lameshur Bays. This reef slopes to a depth of about 14 m where it ends in a well-defined sand channel which separates the base of the reef from a seagrass bed. We selected the Lameshur Bays for long-term study sites because they are in the core of the biosphere reserve and relatively undisturbed by human activities.

The permanent transects lie along the 12 m depth contour. Twenty-three hard coral species occur in the transects, with an additional 10 species observed elsewhere on the reef. We surveyed the transects in January, June/July, and November 1989 (following Hurricane Hugo); March, August, and November/December 1990; and in June 1991 (see Rogers et al. in press, for details).

Changes in Coral Reef Structure After Hugo

During Hurricane Hugo, powerful storm seas fragmented and overturned coral colonies. Waves hurled fragments or entire colonies of coral into other colonies leaving visible impact scars. Coral rubble collected in large piles in sand channels and other depressions in the reef. Damage was patchy, with some portions of the reef exhibiting more destruction than others. This patchiness, noted in other studies of storm damage, reflects differences in reef depth and structure, as well as the differing susceptibility of reef organisms to physical damage (Woodley et al. 1981).

At some sites around St. John, the storm surge transported loads of sediment and buried coral and gorgonian colonies. Off Yawzi Point, however, we did not observe smothering by sediments. Water quality was poor due to turbidity associated with rainfall during and after the storm and suspension of reef sediments. However, the turbid conditions probably did not last long enough to have serious deleterious effects on the reef organisms.

The following are some of our key findings at the Yawzi Point site since Hurricane Hugo:

- Living coral cover: In the November 1989 survey, the living coral cover showed a significant decrease, from about 20 percent to about 12 percent, a drop of about 40 percent (Fig. 1). Coral cover has not increased significantly in subsequent surveys, although there has been some healing of coral scars.
- Diversity: The dominant coral species, star coral (*Montastrea annularis*), has shown a statistically significant decline but remains the most abundant species. Neither the diversity (H') not the evenness (J') of the survey transects increased as a result of the storm.
- Substrate: The amount of substrate available for colonization (pavement and dead coral) increased significantly following the storm.
- Topographical relief: Although one would expect a decrease in topographical complexity after a major storm, especially on reefs dominated by branching species such as *Acropora palmata*, we did not observe any decrease at the Yawzi Point site. Topographical relief could actually increase after a storm if coral fragments and colonies were transported into the transects or if colonies in the transects split into several fragments.
- Algal cover: Macroscopic algal cover increased dramatically immediately after the storm and then fell to pre-storm levels by March 1990. Algal cover had risen again by the November 1990 survey and remained high in June 1991.

Changes in Algal Cover

The dramatic shifts in algal cover observed after Hurricane Hugo are probably the result of a combination of factors. Monitoring of fish populations indicates a decline in herbivorous fishes around Yawzi Point after the storm, reducing grazing pressure on reef algae (Beets and Friedlander 1990). By March 1990, when macroscopic algal cover had declined in the transects, parrotfishes and surgeonfishes had significantly increased (Beets and Friedlander 1990). Macroscopic algal cover may also have declined because algae were dislodged by strong currents or wave action.

We do not know if grazing pressure in the Lameshur Bays has been reduced because of overfishing, a decrease in fishes at the site as a result of Hugo, or a decrease in the number of the herbivorous black sea urchins *Diadema antillarum* during the Caribbean-wide epidemic (D. Levitan pers. comm.). These urchins are presently not abundant at the study site.

Coral Reef Recovery

Recovery of hard coral populations takes place through 1) settlement, survival, and growth of sexually produced coral recruits; 2) healing and regeneration of damaged colonies; and 3) growth of coral fragments (e.g., Connell 1973, 1976, 1978, Endean 1976, Loya 1976, Highsmith et al. 1980, Pearson 1981, Highsmith 1982). The rate of recovery will be affected by factors such asthe morphological and life-history characteristics of the dominant species, the nature of the damage sustained by that species, changes in algal cover, and the occurrence of additional storms.

In 1980, Hurricane Allen devastated the Discovery Bay reef in Jamaica causing the greatest mortality among the most abundant branching species, *Acropora palmata* and *Acropora cervicornis* (e.g., Porter et al. 1981, Woodley et al. 1981, Knowlton et al. 1990). Because *Montastrea annularis*, a slow-growing species with low rates of recruitment (Bak and Engel 1979) is the dominant coral at our study site off Yawzi Point, recovery will probably be comparatively slow. As a result of Hurricane Hugo, live cover by *M. annularis*, decreased by about 35 percent at Yawzi Point, and 34 percent at a nearby reef (Edmunds and Witman, in press). The new substrate created by the storm may provide additional settling surfaces for other hard coral species such as *Agaricia agaricites* and *Porites porites* which have relatively high rates of recruitment (Bak and Engel 1979). However, colonization, survival, and growth of coral recruits will only occur in the absence of intense competition from algae.

Human activities before and after storms can influence not only the speed but also the nature of recovery. For example, extreme overfishing in Jamaica has reduced the populations of herbivorous fishes, resulting in algal smothering of small corals and algal encroachment on the periphery of larger colonies (Woodley 1989). Algal biomass has also increased because of mortality of the sea urchin *Diadema antillarum* (Hughes et al. 1987). Hughes et al. (1987) observed dramatic declines in coral cover (up to 60%) because of competition with algae.

Recovery will be delayed by natural processes such as additional storms, intense predation, algal overgrowth, and coral diseases. Populations of the once-dominant reef-building coral *Acropora cervicornis* have failed to recover at the Discovery Bay reef after destruction by Hurricane Allen in 1980 in spite of this species's fast growth rate, because of a combination of factors, including predation and algal growth (Knowlton et al. 1990, Hughes et al. 1987). Hurricane Gilbert smashed the Discovery Bay coral reef 8 years after Hurricane Allen.

Even in the absence of major additional storms,

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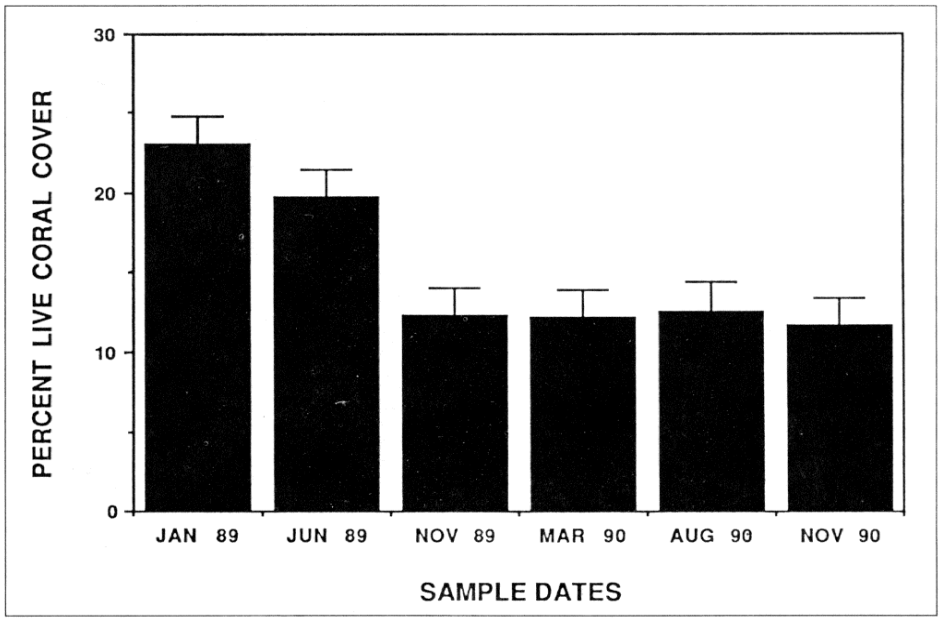

Figure 1.

Mapping and Describing the Soils of St. John

The National Park Service and Soil Conservation Service (SCS) are cooperating in a study to map and characterize the soils in several watersheds on the island of St. John. Both agencies are interested in monitoring soils to detect changes that result from local climate variations or natural processes of plant community succession and in augmenting the limited database on moisture and temperature of tropical soils.

In addition, careless and unregulated clearing and development of lands both within Virgin Islands NP ("inholdings") and adjacent to the park's boundary raise concerns over erosion and runoff of sediment into nearshore waters. Detailed data on the islands's soils should lead to greater understanding of the processes that influence the stabilization of terrestrial uplands.

The SCS will use the data collected to better understand the effects of different plant communities, and soil temperature and soil moisture regimes, on soil-forming processes in the semi-arid Caribbean setting. Ultimately, SCS hopes to improve its ability to predict a given soil's behavior under various, specific types of management.

Currently, the SCS is updating the U.S. Virgin Islands Soil Survey. Soils in the Cinnamon and Lameshur watersheds were mapped in July 1991. SCS will study soils occupying dominant landscape positions within each watershed and soils associated with the permanent vegetation plots in the park. Vertical soil profiles will be excavated, sampled, and analyzed with assistance from the National Soil Survey Laboratory.

Monitoring of changes in vegetation in permanent plots and changes in the physical and chemical nature of the associated soils will help elucidate critical soil/plant community interactions and increase knowledge of Caribbean forest structure and dynamics. Automated data collection instruments have been installed in the Lameshur watershed near the University of Wisconsin plots to record hourly changes in soil temperature and moisture at depths of 4, 8, and 20 inches.

This cooperative project on soils began in August 1991 and will continue for at least three years. It is hoped that additional funding can be found to support collection of especially valuable long-term data on the soils of St. John.

John Davis, *Soil Conservation Service*
Caroline Rogers, *National Park Service*

***Collecting data** on soil temperature and moisture.*

Hurricane Effects *(Continued from page 8)*

recovery will be delayed and additional damage may occur if loose coral fragments, detached boulders, and rubble are tossed around in strong currents. In cases where the actual framework of the reef structure has been altered, re-establishment of the pre-disturbance topography may never occur.

Future Plans

We plan to continue monitoring of the Yawzi Point study site, and an additional site which we established at Newfound Bay, off the east shore of St. John. Here, one 100 m long transect was installed at a depth of about 10 m. This transect was surveyed in August 1990 and March 1991. In 1991, Dr. Bill Gladfelter conducted quantitative surveys of gorgonians and sponges along the Yawzi Point and Newfound Bay transects to augment the data we have obtained on hard corals.

Current programs establishing long-term monitoring of coral reefs should start to enable scientists to differentiate long-term fluctuations on the reefs from responses to anthropogenic and natural disturbances (Brown and Howard 1985). As Hatcher et al. (1989) point out, "the non-equilibrial nature of coral reef communities makes it difficult to determine "standard" reef conditions against which to evaluate impacts". Major progress in understanding recovery processes will require more information not only on hard coral populations but also on gorgonians, anemones, sponges, fishes and the other organisms which contribute to the spectacular diversity of coral reef systems.

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Rogers is NPS Research Biologist at Virgin Islands NP.

Flora of St. John

The preparation of a comprehensive flora for the island of St. John is progressing well after many consecutive years of field work. The island has been thoroughly explored, in a search for all species of vascular plants. Many plant specimens have been collected and deposited at the herbarium of the Virgin Islands National Park for reference and further study.

Pioneering work was done by Dr. Roy O. Woodbury (retired Professor from the University of Puerto Rico) who collected the first specimens and published a checklist for the plants on St. John. He discovered four species which proved to be new. His work constitutes the starting point for this floristic project.

Additional field work has been done in an effort to collect every species of vascular plant on the island. As a result, a few more species have been added to the checklist, and the information on phenology and distribution of the species have been expanded. The status of the rare and endangered species of plants is better understood as new populations have been found.

The "Flora of St. John" will contain complete descriptions of the vascular plants, and information about distributions and local uses. Two hundred line drawings will illustrate about 400 of the 800 species occurring in St. John. The descriptions are primarily the work of Dr. Pedro Acevedo with some contributions by a few colleagues from the Smithsonian Institution. This work will be published in two volumes, each one describing about 400 species. The manuscript for the first volume should be ready in October 1992.

Dr. Pedro Acevedo
Smithsonian Institution

Assessment of Coral Reef Fishes in Virgin Islands National Park

By Jim Beets

Disturbance has been demonstrate to be extremely important to community structure (Sousa 1984). Coral reef fishes are particularly vulnerable to disturbance. When different components of the coral reef community are disturbed either by natural or anthropogenic disturbances, species in the fish assemblage are differentially affected based on their association, e.g., plankton-planktivores, algae-herbivores, invertebrates-predators. Catastrophic storms tend to affect most trophic levels of fishes by disrupting their food supplies or, more generally, by affecting their shelter. Lack of shelter, which enables fishes to avoid predation, may limit fish abundance.

Observed effects of Hurricane Hugo and recovery

The sustained monitoring program, which began in 1988 in Virgin Islands NP, has provided a rare opportunity to observe the effects of a hurricane on coral reef fishes and their subsequent recovery. We selected three different reef types around St. John and sampled them monthly with a random point visual technique (Bohnsack and Bannerot 1986). We censused fishes in the two predominant zones present on the fringing reef system within the park, the upper forereef and lower forereeef.

Census data demonstrated that the abundance of all fish species declined at the monitoring sites as a result of Hurricane Hugo and remained depressed for the next three months (Fig. 1). Some herbivorous fishes (primarily surgeonfishes) significantly increased following the storm, probably in response to the enormous increase in algal growth (Mann-Whitney U Test, $P<0.001$).

Most species showed substantial recovery during the first year following Hurricane Hugo (e.g., parrotfishes, Fig. 1). Although total fish abundance has returned to pre-storm levels, the proportion of the surgeonfishes was greater one year after the storm than before it (Fig. 1). There herbivorous fishes have maintained much greater abundance compared to pre-storm levels.

A few species, such as planktivorous fishes (e.g., *Chromis* spp.) were greatly affected by the storm and have shown very slow recovery. The abundance of most species is dominated by juveniles.

The storm had a varied effect on different fish species within the study area. Most larger species were probably displaced from the shallow water monitoring sites to deeper reefs as previously observed by Walsh (1983) for a reef in Hawaii. Predation of small individuals due to habitat loss and displacement was also certainly an important factor. Declines in abundance, habitat shifts and behavioral changes in many species were observed during the first month following the storm, as described in previous investigations (Woodley et al. 1981, Kaufman 1983, Walsh 1983). Displaced species appeared to redistribute themselves during the several weeks following the storm. The redistribution of fishes and colonization by juveniles contributed to recovery in abundance of most species during the 6 months after Hugo.

Storm-generated change in coral assemblages in exposed sites, especially the decrease in topographic complexity, decreased the amount of shelter available for many fish species, especially cryptic species, such as basslets, cardinalfishes, blennies and gobies, and for recently-recruited juveniles. The loss of topographic complexity and decline in living coral cover may favor the abundance of larger, schooling herbivorous fishes and turf-tending damselfishes living in the coral rubble. The effect of the hurricane on reef fish assemblages was most pronounced in areas where branching corals (particularly, elkhorn and staghorn) previously comprised the structure of the reef and shelter for fishes was dramatically reduced. The slow recovery of some planktivorous species may be due to reduced recruitment or slow recovery of the associated plankton community, which has been shown to change following major storms (Woodley et al. 1981).

What's in the Future?

Although we have been able to observe the local effect of a major storm, we need a more thorough understanding of coral reef fish ecology and a determination of the best methods for monitoring reef fishes. We will continue to sample different habitats and to evaluate various methods to provide a more complete view of the fishes and fisheries within the park and surrounding shelf area. Many questions may not be answered until we have accumulated several years of data. We can expect natural fluctuations in species abundances, but we may see shifts in species dominance based on successful recruitment, changes in ecological and oceanographic conditions, and human influence.

One of our greatest concerns is the effect of commercial, artisanal, and sport fishing on fish assemblages within the park. We look forward to cooperating with the National Park Service on a major fisheries project to begin this year.

Dr. Beets is Chief of Fisheries, U.S.V.I. Division of Fish and Wildlife.

(Literature cited on page 11)

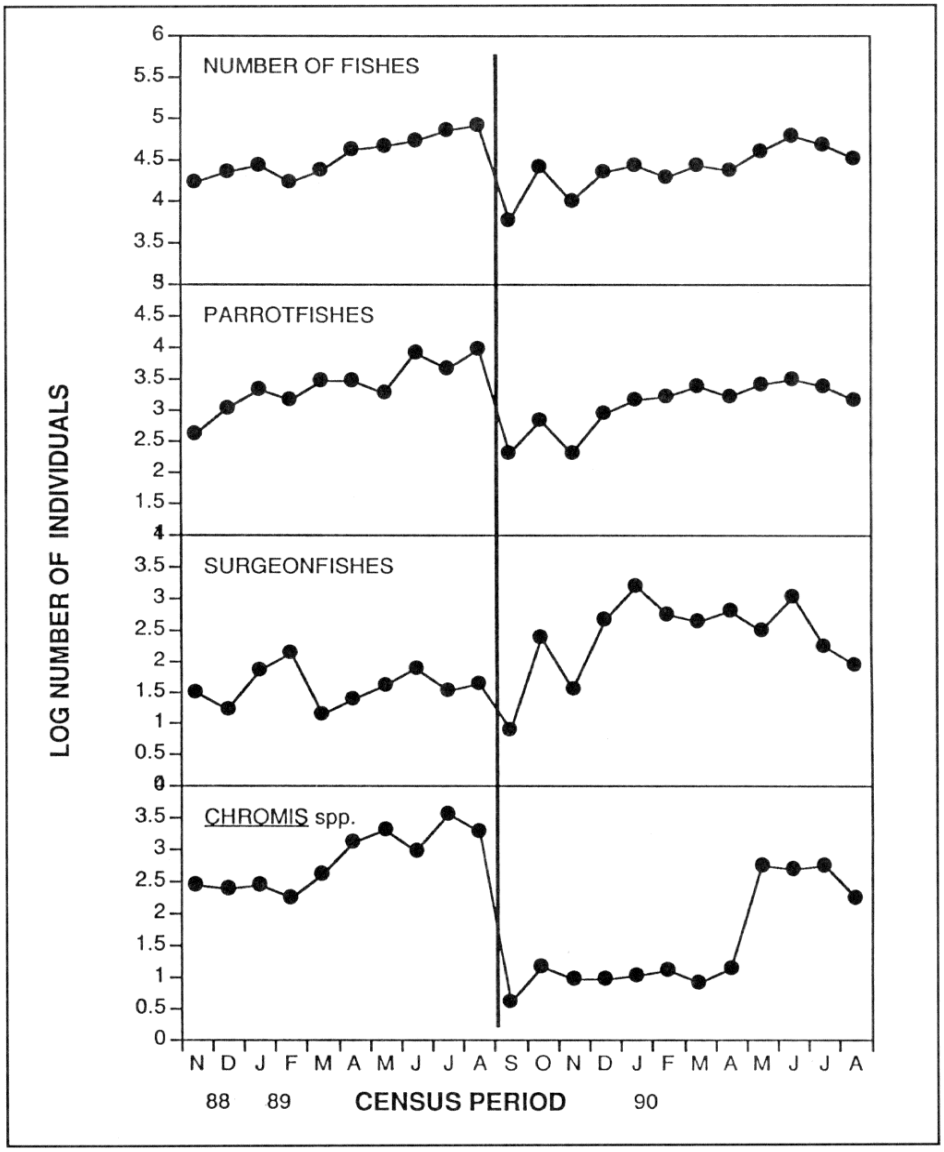

Figure 1. *Relative changes in total abundance offishes and of dominant fish taxa before and after Hurricane Hugo. Data are presented log-transformed (LN X + 1). Parrotfishes and surgeonfishes are herbivorous species;* Chromis *spp. are planktivorous damselfishes. Vertical line represents date of Hurricane.*

Monitoring Water Quality in Virgin Islands National Park

By Giglia Beretta and Craig Tobias

While over half of the island and 2,287 ha of the surrounding waters are protected within the boundaries of Virgin Islands NP, (VINP). St. John is subject to the same types of developmental pressures that are currently affecting numerous other Caribbean islands. The waters that surround the island and the numerous white sand beaches are perhaps the biggest attraction to the park for visitors from all over the world. More fundamentally, the nearshore waters provide important habitats for complex communities. The characteristically clear waters (low nutrient levels), provide ideal conditions for growth of corals, seagrasses, and a host of other marine organisms.

Sparked by tourism-based economies, development in the Caribbean is occurring at an alarming rate and may prove to be the single greatest pressure facing tropical marine ecosystems. Over the past 25 years, visitation to Virgin Islands National Park has increased drastically, with many visitors arriving on cruise ships and small boats. In 1966, an average of fewer than 10 boats per day used park waters. By 1989, this figure had jumped to averages of 70-80 boats per day in the park (Rogers et al. 1990). As with many islands in the Caribbean, there is a need for good baseline data on water quality. Such data are essential to researchers and park managers as tools for understanding and pinpointing changes affecting marine ecosystems.

In 1988, VINP began its water quality monitoring program encompassing sites both inside and outside the park. Twenty-nine sites, (16 within VINP and 13 outside of VINP), are sampled on a monthly basis. The parameters measured include salinity, dissolved oxygen (D.O.), conductivity, pH, temperature, and turbidity. Salinity, D.O., conductivity, pH and temperature are measured in situ, at the 'surface' (at a depth of 1m), using a Hydrolab Surveyor II Datasonde. Beginning in 1989, subsurface temperatures have also been measured at Lameshur Bay (on the island's south shore), using Ryan Tempmentors. The Tempmentors are secured at the site of permanent transects used to monitor coral cover at sections of the reef, and record temperature every 2 hrs. Turbidity, (water clarity), is evaluated in three ways: 1. by using a Secchi disk, to estimate the depth at which the disk is no longer visible, 2. by analyzing 150ml samples taken from 15-20cm depth, with a Turner TD 40 Nephelometer, and 3. by lowering a Martek Model XMS Transmissometer over the side of the boat to measure percent light transmission in the water column.

Some Key Findings

- **Salinity, pH, and Conductivity**

Apparently, there are no inter-annual trends with salinity, pH, and conductivity. There was little fluctuation between sites and years for these parameters. Averages for all sites from January 1988 until March 1991 were 35.52ppt, 7.58 and 53.87mmhos/cm, respectively. Marine systems, primarily due to greater mixing, generally experience little variation of these parameters. This is especially true for St. John which possesses no substantial estuaries or fresh water input, and has a relatively well flushed coastline.

- **Dissolved Oxygen**

The average D.O. concentration for all sites for this sampling regime was 6.63mg/l. Reef Bay, Rendezvous Bay, and Chocolate Hole had markedly higher average D.O. concentrations than the mean at 8.02, 7.15, and 7.79mg/l respectively. Dense seagrass beds, (dominated by *Thalassia testudinum*), characterize these sites, elevating local dissolved oxygen concentrations as a result of photosynthesis. In contrast, the lowest average D.O. concentration of all sites was 5.94mg/l at Cruz Bay. This is not surprising, as this very shallow site has a barren, muddy bottom, with little flushing, but constant resuspension of sediments.

- **Temperature**

Temperature fluctuated little over the sampling period. An overall low of 24.47°C was recorded in March 1989 at the ferry dock in Cruz Bay, while the highest surface temperature was recorded in August 1991 at Coral Bay (30.82°C). A comparison of temperature data taken at Lameshur Bay for monthly surface temperatures (measured with a Hydrolab Surveyor II), and from the subsurface tempmentor shows slight increases at both depths. Mean surface and subsurface temperatures increased from 27.02°C to 27.90°C and from 27.10°C to 27.49°C respectively, from 1989 to 1990. Temperature data, especially from the Lameshur Bay site, is an integral part of a database established to monitor temperature changes in association with coral bleaching episodes (as increases in water temperature have been suspected of triggering bleaching).

- **Turbidity**

Over the past four years, turbidity has increased for sites outside of park boundaries as well as for sites within the park. However, for each year, turbidity values have been consistently higher for sites outside of the parks boundaries (Fig.1). Trends in transmissometry (initiated in 1989), support our findings with the nephelometer turbidity data.

Measurements of percent light transmission and nephelometry readings indicate that Cruz Bay, Great Cruz Bay, Fish Bay and Coral Bay Harbor, all outside of the park, have the highest turbidity measurements of the 29 sites sampled. All are extremely well sheltered bays with naturally poor water circulation. However, it is doubtful that the relatively high turbidity encountered in these bays is due solely to geographic location, and/or physical structure of the embayments. Because of their location outside VINP, these sites experience upland development of the watersheds draining into the bays, and virtual unregulated commercial use of their waters. The significantly poorer water clarity of sites outside of VINP boundaries indicates that restrictions on development and commercial use of embayments within the park is contributing to higher water quality of the bays protected within the park.

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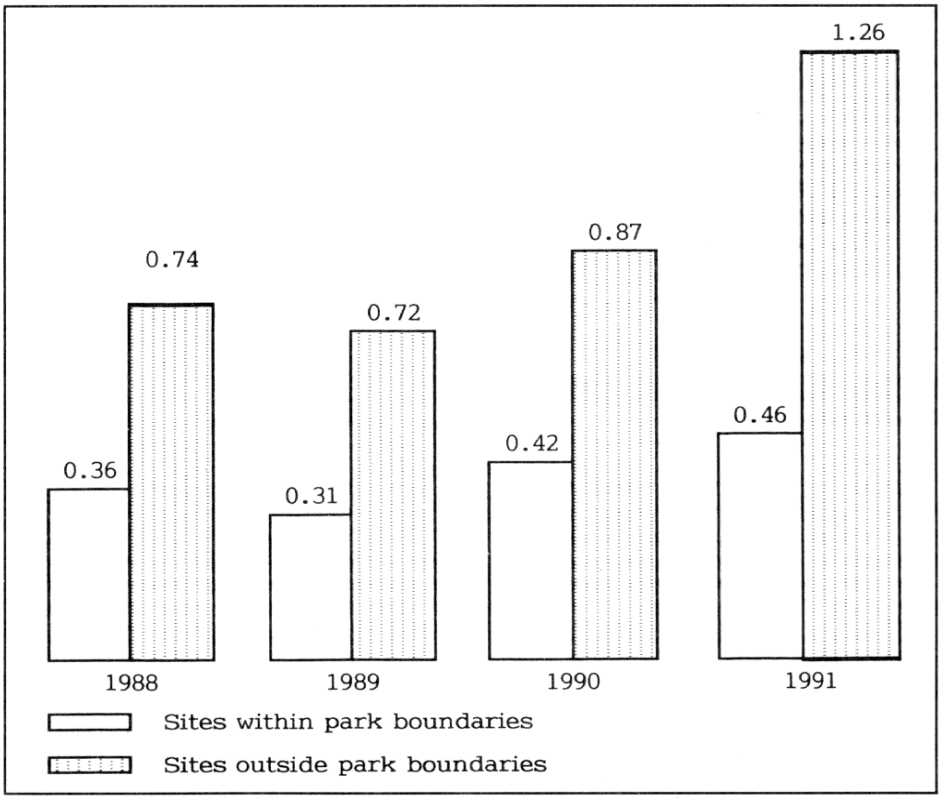

Figure 1. *Mean Turbidity (NTU) for Sites Inside and Outside of Park Boundaries*

Reef Fishes *(Cont. from p. 10)*

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Population Studies of Migratory Birds in Virgin Islands National Park

By Robert A. Askins and David N. Ewert

The majority of the individual songbirds nesting in the deciduous forests of eastern North America migrate to the West Indies, Central America and South America during the winter. They typically spend more than six months in tropical winter habitats. Until recently relatively little was known about their habitat requirements during the winter, but increasing concern about declining populations of many migratory songbirds combined with widespread alarm about the rapid destruction of tropical forests has led to a flurry of research on this subject (Terborgh, 1989; Askins et al. 1990). In 1987 we initiated a study of the ecology and behavior of migrants in the Virgin Islands, particularly in Virgin Islands NP on St. John. This study has not only yielded information about the winter ecology of migratory birds, but also about the distribution of resident species and (unexpectedly) the impact of a major hurricane on bird populations.

Habitat Requirements of Migratory Songbirds in Winter

Unlike other islands in the Virgin Islands group, St. John has large continuous tracts of moist tropical forest and dry woodland. Establishment of Virgin Islands NP in 1956 insured protection of much of the forest that was growing back on land that had been covered with sugar cane or pasture in the 19th century (Tyson, 1987). After completing an intensive survey of birds on St. John in February and March of 1957, Robertson (1962) concluded that some species of winter-resident migrants that were considered rare on nearby islands were widely distributed in the moist forests of St. John. Moreover, records from Christmas Bird Counts indicate that St. John has a higher diversity of winter-resident warblers than the other major islands in the U.S. Virgin Islands, St. Croix and St. Thomas (Pashley and Martin, 1988). These results suggested that Virgin Islands NP might include important habitat for migratory songbirds.

To assess the importance of different habitats for wintering migrants, we surveyed birds in the dominant habitats on St. John and St. Thomas. Land-use patterns on the two islands are dramatically different; St. John is 86 percent forested while 62 percent of St. Thomas is covered with commercial and residential areas, and only 38 percent is forested (Askins et al., in press). The remaining forest and woodland on St. Thomas is in the form of relatively small, disjunct patches. Our primary goal was to compare similar natural areas on the two islands to determine if forest fragmentation on St. Thomas had resulted in relatively low densities of migratory birds.

We surveyed birds at 218 points scattered across the two islands (Askins et al., in press). We counted all birds detected within 25 m of the point during a 10-minute observation period. Survey points were located in moist forest, dry woodland, and artificial habitats (e.g., hotel grounds and residential areas). Vegetation surveys were completed on a plot centered at each survey point.

We recorded an impressive diversity of winter residents during these surveys: 13 species of warblers and one species of vireo (Askins et al., in press). Like Robertson (1962), we found that the density of winter residents is more than three times higher in moist forests than in dry woodlands, and that some species were largely restricted to moist forests. Artificial habitats had relatively low densities of winter migrants and many species were never recorded in this habitat. Consequently, moist forest is a critical habitat for winter residents.

On St. Thomas, most moist forests are in steep-sided ravines (guts) surrounded by residential areas or on mountain tops that are being subdivided for housing. In contrast, the moist forests of St. John are embedded in extensive tracts of dry woodland. The remaining moist forests on St. Thomas have a vegetation structure similar to those on St. John, but the density of winter residents is significantly lower; we detected an average of 1.9 winter-resident birds per survey point on St. John compared to only 0.6 per point on St. Thomas (Askins et al., in press). Moreover, even the artificial habitats on St. John have a higher density of winter residents than similar habitats on St. Thomas. Degradation and fragmentation of natural habitats on St. Thomas have apparently resulted in a relatively low density of wintering migratory songbirds.

Maintenance of an abundance and diversity of wintering songbirds in the U. S. Virgin Islands will depend upon protection of the remaining tracts of moist forest, especially the relatively large tracts in Virgin Islands National Park. Some of these tracts, such as the upland forest on Bordeaux Mountain, are threatened by development on private land. A long-term threat is the pressure for road construction and recreational development along the south shore of St. John, where there are forested coastal basins.

Social Behavior of Wintering Songbirds

Our surveys revealed that wintering songbirds often occurred in mixed species flocks or aggregations. If participation in mixed flocks is important for wintering migrants, then forest fragmentation might have a negative effect on them if individuals become isolated and are unable to form flocks. To assess the distribution and frequency of mixed flocks, we surveyed transects in remnant patches of moist forest on St. Thomas and in larger moist forests on St. John (Ewert and Askins, 1991).

Most of the individuals detected in flocks (91%) were migrants. The two most abundant winter residents, Northern Parula (*Parula americana*) and Black-and-white Warbler (*Mniotilta varia*), were especially frequent in flocks. In contrast, only 17 percent of the flocks included permanent residents. Many of the groups of migratory birds moved together in a cohesive flock for more than 20 minutes, indicating that these groups were not merely chance aggregations at a favorable feeding site.

When we compared the frequency of flock participation and the size of flocks on the two islands, we found no significant difference. The average number of birds per flock (4.0 individuals of 3.1 species) was similar on St. John and St. Thomas despite the lower density of migrants on the latter island. Thus, there is no obvious relationship between habitat fragmentation and flocking behavior. However, survivorship of birds in flocks of similar size and composition may differ on the two islands. This requires further study.

Distribution of Resident Species

Unlike migratory birds, resident birds are more abundant in dry woodland than in moist forest (Robertson, 1962; Askins et al., in press). Although areas of dry forest are larger and more continuous on St. John than on St. Thomas, the number of species and individuals detected per survey point are similar on the two islands, indicating that habitat fragmentation does not have a major effect on either the density or diversity of resident birds. Hence, in this case the main concern may be the direct effect of habitat loss rather than to indirect effects caused by fragmentation of the remaining habitat.

Impact of Hurricane Hugo on Bird Populations

Hurricane Hugo hit the Virgin Islands in September, 1989. We visited St. John in January, 1990 to study the effect of the storm on bird populations. We completed surveys at 62 points in moist forest and dry woodland, compared to 90 points in these two habitats in 1987 (Askins and Ewert, 1991). The average number of individual permanent residents per survey point was significantly lower after the hurricane. Most of the species that showed substantial declines were species that feed primarily on fruit or nectar, a pattern that has been documented in several other studies of the impact of hurricanes on birds (Wunderle et al., in press). For example, Scaly-naped Pigeon (*Columba squamosa*), Antillean Crested Hummingbird (*Orthorhynchus cristatus*) and Bananaquit (*Coereba flaveola*) all showed significant declines. Most wintering migrants had similar densities before and after the hurricane, but the most abundant species (Northern Parula) showed a significant decline (Askins and Ewert, 1991).

Substantial declines of some resident bird populations after hurricanes indicate that island populations may be vulnerable to extinction, especially if their populations are already greatly reduced as a result of habitat destruction. The possibility of severe population declines due to hurricanes must be considered in any management plan for threatened or endangered species in the Virgin Islands. As much favorable habitat as possible should be protected for these species, with special attention to protection of sites with different exposures, elevations and slopes to allow for differences in susceptibility to hurricane damage.

Future Research

Permanent survey points have been established in Virgin Island NP to facilitate long-term monitoring. We plan to determine population trends in migratory song-

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Water Quality Monitoring

(Continued from page 11)

Future Plans

We hope to continue the monitoring program to establish a sufficient database to assess long-term trends in water quality in the park. We also hope to start analyzing bacterial contaminants, in particular, fecal coliforms, for sites adjacent to coastal developments developments or heavily visited bays.

Giglia Beretta is a Biological Technician at Virgin Islands NP; Tobias formerly was a Biological Technician on the park staff.

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Seagrass Disturbances in Great Lameshur Bay, St. John

By Lisa Muehlstein

Seagrass habitats are extremely important components of coastal ecosystems; they stabilize bottom sediments and improve water clarity, exhibit high rates of productivity, and provide shelter and nursery grounds for many commercially important species. Seagrasses also serve as a direct food source for a number of different animals, most notably the green sea turtle (Dawes 1981, Zieman 1982). The seagrass communities in the Virgin Islands are subjected to many stresses, including pollution, development, recreational boating, disease and storms.

Great Lameshur Bay, St. John, has been the site of a multi-faceted seagrass study over the past three years, including the documentation of disturbances and the establishment of a long-term ecological study. This bay is within Virgin Islands National Park and Biosphere Reserve and receives less pressure from recreational use and development than other areas of the park. However, the seagrass community has been stressed significantly over the last three years.

Bluegreen Algal Overgrowth

In 1989, an unusual bluegreen algal overgrowth appeared in the bay following a tropical storm. In May, the overgrowth covered approximately one-third of the seagrass community and extended over the fringing reef along the western edge of the bay. In some areas, this bluegreen mat was 20-30 cm deep. A decrease in the vigor of the seagrass plants was apparent in these areas. Leaves were pale and senescing, apparently from lack of light and a decrease in available oxygen. The alga was tentatively identified as a species of *Schizothrix*. The cause of the overgrowth remains unknown. The tropical storm may have caused a flushing of the fringing mangrove system, releasing high levels of nutrients into the bay and stimulating the algal bloom. Hurricane Hugo wiped out the bluegreen algae, along with the overgrown seagrasses.

Hurricane Damage

During Hurricane Hugo, dislodged coral heads, tree trunks and other debris were carried into the seagrass bed by storm waves, leaving behind severely damaged plants. In many areas, seagrass plants were almost completely buried. In Great Lameshur, the seagrass bed was extensively damaged, with large blowouts reaching a maximum of 20 m by 20 m and up to 1 m deep. Several blowouts were marked after the storm to document recovery and succession within the seagrass bed. Measurements were taken on a quarterly basis to record areal change of the blowouts. Recovery of seagrasses could take several years partly because of extensive damage to the terminal meristems of the rhizomes (Fuss and Kelly 1969, Tomlinson 1974). Similar blowouts took 5 to 15 years to recover (Patriquin 1975). It took up to six months following the storm for sediments to begin to fill in the extensive pits. Fifteen months following the storm calcareous green algae including *Penicillus* spp. and *Halimeda* spp. began to colonize the bottom of the blowouts. This colonization may be the initial successional stage within a seagrass bed (Zieman 1982). However, the size of the blowouts actually increased as damaged seagrass plants continued to die back. Eighteen months after the storm, some new growth and colonization by manatee grass, (*Syringodium filiforme)* and turtlegrass, (*Thalassia testudinum)* was apparent. The size of the blowouts appeared to be stable, and no increase in area was observed. Twenty months after the storm, the blowouts appeared to be diminishing in size, reflecting more colonization by turtlegrass. Full recovery of the blowouts is likely to take several more years.

Disease

Disease is another stress affecting turtlegrass in Great Lameshur Bay. A pathogenic species of *Labyrinthula* has been isolated from turtlegrass in this bay as well as other bays around St. John, St. Thomas, and St. Croix. In laboratory tests conducted according to Muehlstein et al. (1988), the isolates of *Labyrinthula* have been conclusively demonstrated to be a pathogen of turtlegrass. Although no major disease-related declines have been documented in Great Lameshur or other local bays, the stress of disease is present and represents a threat to the habitat. Both temperate and tropical seagrass habitats have suffered major declines from disease over the last 10 years (Short et al. 1987, Muehlstein et al. 1988, Robblee et al. 1991).

Long-term Monitoring

In an effort to document the current status of the seagrass habitat and the effects of disturbance, a long-term monitoring project has been established in Great Lameshur Bay. Three 250 m permanent transects have been installed for the collection of basic ecological data. Measurements of seagrass density, community structure, and seagrass productivity have been taken at quarterly intervals for the last two years. Preliminary analysis indicates an unstable community structure with fluctuating populations of macroalgae, dominated by *Penicillus* spp. and varying densities of manatee grass and turtlegrass. Productivity is low in comparison to other areas. The instability of the community may reflect the level of disturbance over the last several years. It is extremely important to maintain a monitoring program, not only to document changes within the system but also to provide a solid data base for future resource management decisions.

Dr. Muehlstein is Assistant Professor, Department of Biology, University of Richmond.

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Migratory Birds in Virgin Islands NP

(Continued from page 12)

birds in relatively undisturbed habitats in the park. Consistent declines of migrants in these habitats would be evidence for an overall population decline, perhaps due to habitat changes in the breeding areas or on the migratory routes. At the same time, we can assess population changes of permanent residents, particularly rare or localized species. We also plan to expand our research on the ecology and behavior of particular species of wintering migrants.

Askins is an Associate Professor of Zoology at Connecticut College, New London, CT; Ewert is a biologist with The Nature Conservancy, East Lansing, MI. *Their research was supported by the National Geographic Society, the World Nature Association and the U.S. NPS.*

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letters

To the Editor:

As one who was lucky enough to be a participant in the Vail symposium, I read your editorial in the Winter 1992 issue with interest. I am in general agreement with the cautious optimism you expressed. Others, however, do not share this point of view.

Dr. Roderick Nash, one of the Service's most articulate critics yet ardent supporters, has expressed his disappointment in the recommendations of the symposium. He feels that the symposium participants missed the opportunity to articulate a strong National Park Service commitment to something Nash labels "planetery modesty."

Dr. Nash describes planetary modesty as a recognition that human beings are not the only passengers on Spaceship Earth. We must, Nash argues, live in harmony with nature because we have no more right to dominate nature than we do to dominate another individual. Aspens, canyons, periphyton, and all the other components of our ecosystem have a right to exist, not merely because of their value to us, but because they are an integral part of the world in which we all live.

This is revolutionary stuff – rocks have rights! – and the NPS is the perfect agency to pitch this vision to its visitors if only we have the courage to adopt it.

As is Nash, I am disappointed that we didn't take a stronger stand about the NPS and its potential role as a leader in resource stewardship. The Service seldom leads from the front. When was the last time we took a strong stand on major environmental issues such as overgrazing of public lands, irresponsible mineral development, or the failure to add to the nation's Wilderness Preservation System? When was the last time we told the ORV people to take a hike? We are going to be eaten alive by groups such as People for the West if we are not able to demonstrate where we stand, in stark contrast to what they are advocating.

Finally, quoting the environmental leadership section, while I applaud the concept of "leading by example," what examples are we going to demonstrate? We aren't progressive about recycling, we don't design for energy efficiency or site compatibility, we don't promote the use of alternatives to fossil fuels, we don't do much about getting visitors out of their cars, we favor commercial interests over private users in such areas as river permit allocations, we allow snowmobiles and outboard motors in pristine places such as Voyagers and Grand Canyon, we permit development in major resource areas, we spend more money fighting drugs than ARPA violations, we urge our superintendents to do more with less when we should have the courage to tell them to do *less* with less, and every year we lose ground in the preservation and protection of cultural resources.

It's not a pretty picture.

Rick Smith, Associate Regional Director
National Park Service Southwest Region

To the Editor:

The Winter 1992 issue of ***Park Science*** contained an editorial reporting excitement that the 75th Anniversary Symposium focused in a tough, no-nonsense, and very specific way on the need for organizational change in the NPS. Hope was expressed that real action will result.

There are good reasons to be hopeful, for top management is listening and the political system appears supportive of action. But Rome wasn't built in a day, and broad reforms will only come about over time. Just as ***Park Science*** urged its readers to get involved to shape the report, I would urge all employees to learn about the Symposium, become advocates, and look to participate directly in the implementation process now evolving.

The preliminary draft of the Symposium report contains major recommendations for reform and dramatic characterizations of agency problems. Describing the Service as "beset by controversy, concern, and weakened morale within," it reports that the Symposium "revealed a deeply disturbing sense that the nation is risking a deterioration of its natural and cultural heritage that not even the most dedicated personnel can effectively prevent." It observes that:

"Perceptions exist among many employees – and not without bases in reality – that good job performance is impeded by lowered educational requirements and eroding professionalism, that initiative is thwarted by inadequately trained managers and politicized decision making, that the Park Service lacks the information and research capability it needs to stand up for itself in Washington, DC, and in the communities that surround the park units, that the mission and the budget of the Service is being diluted by increasing and tangential responsibilities, that there is a mismatch between the demand that the park units be protected and the tools available when the threats to protection are increasingly coming from outside unit boundaries, and that communication within the Service repeatedly breaks down between field personnel and regional and headquarters management that lack or have no recent field experience."

It should be good news to your readers that the report states: "Science and research should form the foundation from which the NPS asserts itself as proactive leader." But, it observes, the Service is "extraordinarily deficient in its capacity to generate, acquire, synthesize, act upon, and articulate to the public sound research and scientific information." To remedy this, it recommends increasing the number of research and resource management professionals, a legislative mandate for research, and new funding.

The report also recommends expanding interpretation and educational outreach, revamping training programs, developing new human resource policies, and moving immediately to reform the park ranger series. Director Ridenour and Dep. Dir. Cables have begun organizing to act on the report, which is due in Washington about the time ***Park Science*** goes to press. A team of senior and mid-level field and Washington personnel has been appointed to propose strategies to implement recommendations, which must first be prioritized for action.

It appears certain that implementation will involve the use of many task and planning groups to develop the action strategies to address the issues. The Director's concept is to involve employees Servicewide in the effort. Team members will recommend these people, and I suggest you contact them and volunteer to participate. Team members are:

Bob Barbee, Maria Burks, Diane Dayson, John Debo, Mike Finley, Maureen Finnerty, Denny Galvin, Paul Haertel, Wallace Hibbard, Steve Kesselman, Ernest Ortega, Stan Ponce, Dick Powers, John Reynolds, Dick Ring, Rick Smith, and Kate Stevenson.

Dick Marks, Nancy Nelson, and I are providing staff support to the Deputy Director, who is leading this effort. We will help coordinate the groups and do what we can to keep things moving along. This is an exciting, hopeful moment in our history. We are receiving a high profile, prestigious document that calls for fundamental change to strengthen and expand the reach of this great organization. We have much to say about making it happen.

Loran Fraser
75th Anniversary Staff Coordinator

Editor's Note: For another slant on the Vail Conference, see the article by Bill Brown, retired NPS historian, in the current issue of the George Wright Society ***FORUM*** *(Vol. 8 No. 4).*

mab notes

Linkage between European and North American biosphere reserves across biomes will strengthen as a result of recommendations made at the meeting of representatives of EUROMAB in Washington, DC, Feb. 5-7. First a little background. These recommendations relate to the *EUROMAB Biosphere Reserves Integrated Monitoring Program*, known as BRIM. This program was launched at the August 1991 meeting of EUROMAB in Strasbourg. BRIM will provide the basis for:

Improving detection and prediction of trends in environmental conditions on continental and global scales; understanding the variability of natural and human caused phenomena and differentiating between the two; understanding the appropriate geographic and temporal scales of environmental problems; producing optimal spatial and temporal resolution and synthesis of information; testing hypotheses; and initiating processes of environmental learning and education.

The program will be carried out by establishing (1) a broad-based network of biosphere reserves that conduct basic inventory and monitoring of biological, physical, socio-economic, socio-cultural, and behavioral parameters; and (2) smaller, representative "subnetworks" for in-depth monitoring and research on special issues.

At present, 26 countries and 166 biosphere reserves are involved in BRIM. Nine countries – the U.S., Canada, United Kingdom, France, Germany, Sweden, and former USSR, Czechoslovakia, and Spain – were represented at the February meeting. In particular, the group recommended further consideration of NPS methodologies for biological inventory assessment and recording information on flora and fauna as a potential model for the EUROMAB program. Mike Ruggiero, Chief of the NPS Wildlife and Vegetation Division, will be working with representatives from Czechoslovakia and Sweden to adapt the NPS model for use in BRIM.

Other recommendations include creation of a EUROMAB directory, which will list contacts, facilities, and activities in the biosphere reserves; assessment of permanent plots in the BRs and development of guidelines for permanent plots; establishment of a pilot global change project in Europe; more emphasis on sociocultural factors at BRs, including case studies on making BRs work on the ground; and various organizational measures to strengthen EUROMAB.

NATO may be shrinking, but the environmental war dictates a growth in trans-Atlantic alliances like EUROMAB.

Napier Shelton
NPS Washington Office

Stream and Floodplain Restoration On Watersheds Disturbed by Mining

By Kenneth Karle and Roseann Densmore

Placer mining for gold has severely disturbed many riparian ecosystems in northern regions. Placer mining involves removing riparian vegetation and topsoil, excavating gravel from the active floodplain, old terraces, and/or the active stream channel, and processing the gravel to remove the gold.

Processing also removes most of the "fines" from the gravel. Until recently, topsoil and fines usually were buried under tailing piles or washed down the stream, and processed rock and gravel were left in large tailing piles. These tailing piles often revegetated very slowly – some more than 50 years old still have little or no vegetative cover.

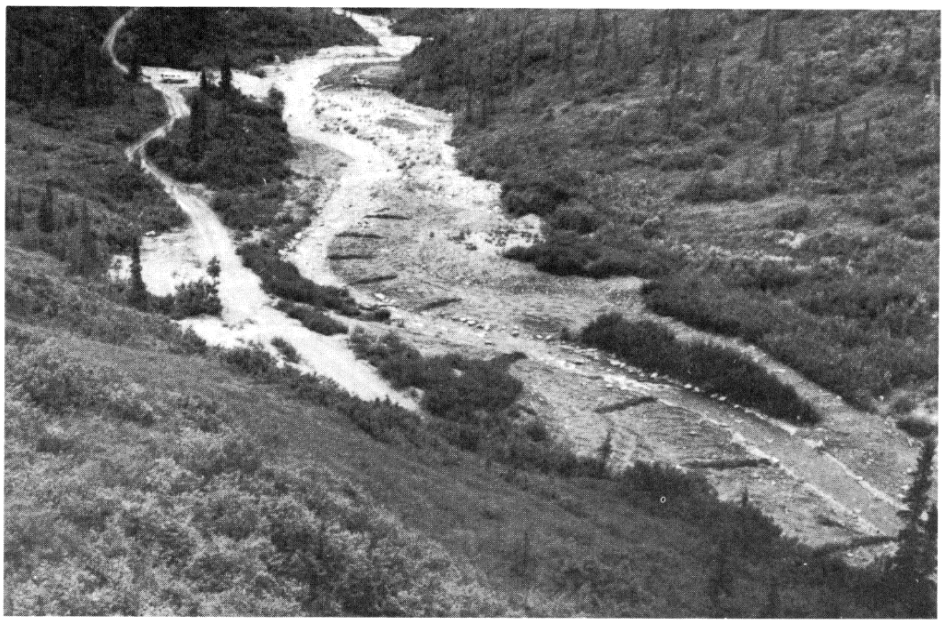
Glen Creek, in the Kantishna region of Denali NP and Preserve (DENA), is typical of many placer-mined streams in the area. It is characterized by significant stream channel adjustments and disfunctioning riparian zones. Specifically, unstable or excessively confined streambeds, as well as over-steep floodplains, are evident along many reaches of the 6-mile length. Piles of mine tailings have replaced much of the native streambed material. Riparian vegetation is absent along most channel bank and floodplain reaches. Floodplain soils, necessary for vegetative recovery, are relocated in separate, distinct piles, or absent altogether. Soil replenishment, normally a function of annual flooding, is impossible because of confined streambeds.

The importance of a properly functioning riparian zone cannot be overstated. Riparian habitat in undisturbed conditions is characterized by greater species diversity, density, and productivity than any other habitat type. In addition to supplying the basic habitat needs of water, food, and cover, riparian habitat provides travel corridors and affects wildlife productivity in adjacent habitats.

Evidence indicates that the value of riparian habitat for wildlife in the Glen Creek watershed and other mined drainages of the Kantishna Hills is severely reduced where large amounts of riparian vegetation and soils are absent (USNPS 1990). Long-term habitat loss for grizzly bear, black bear, moose, furbearers, and birds has been documented. Additionally, aquatic zone habitat has been similarly disturbed. Populations of many of the macro and micro invertebrates, as well as slimy sculpin and grayling, are suspected to have been severely impacted or even eliminated.

With such a disturbed hydrologic regime, any riparian ecosystem recovery from placer mining in the Glen Creek watershed by means of natural processes is significantly hindered. In channel reaches where the streambed is incised and straightened, bed scouring continues to occur.

During annual flooding, erosion of over-steep banks results in excessive sediment loading of the stream. This sediment load is then deposited in the channel downstream in areas of shallower gradient, resulting in additional problems such as cementing of substrates and clogging of benthic invertebrates. Incised stream channels also prevent flood waters from reaching the floodplain, thus interrupting the natural process of floodplain sediment deposition necessary for enhancement and creation of moist, nutrient rich zones.



Brush bars for floodplain stabilization *may be seen on either side of the channel in this aerial view of the lower half of the 1991 study reach on Glen Creek in Denali NP.*

Feltleaf willow cuttings for revegetation *are shown here, along with brush bars for floodplain stabilization on a reclaimed section of Glen Creek.*

Pilot Study

Abandoned placer claims on lower Glen Creek represent a unique opportunity for conducting research to improve riparian habitat. A pilot study was begun in 1991 to evaluate techniques for rehabilitation of disturbed stream channels and floodplains. The study involved a 1400′ reach of Glen Creek, and focused specifically on restoration of over-steep floodplains in that reach. The study's goal was to develop techniques to allow for the evolution of certain hydrologic characteristics such as sinuosity, pool/riffle ratio, and other natural habitat features with minimum construction needs.

Channel adjustments will provide for a streambed capacity to contain a 1.5-year flood, and a floodplain capacity to contain a 1.5- to 100-year flood. Sediment loading from bank erosion and other sources must be minimized. Channel controls, such as riprap or gabions, will not be used, as these generally hinder natural stream restoration.

Methods and Discussion

The BLM, in an attempt to enhance riparian zone recovery in a portion of Badger Creek, Colo., developed a scheme for designing stable channels in coarse alluvium based on pertinent geomorphic, hydraulic,

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Dynamic Fire Modeling using GRASS 4.0

Developed by NPS and University of Arizona

By George Ball, Michael R. Kunzmann, & Peter S. Bennett

The use of Geographical Information Systems (GIS) for static modeling has been a major emphasis for implementation of GIS within the National Park Service. Linking dynamic models directly to existing NPS GIS data bases would provide the manager with the capability of examining "what if" scenarios that are directly related to the landscape area in question. The Advanced Resources Technology group at the University of Arizona in cooperation with the NPS Cooperative Park Studies Unit (CPSU/UA) have been examining the feasibility of incorporating these dynamic GIS programming linkages to existing fire behavior and effects models. A primary goal has been to provide a set of user-friendly GRASS 4.0 programming tools that can extend the range of park management analysis opportunities.

GRASS 4.0 Fire Modules

The Advanced Resource Technology Program at the University of Arizona has been developing, modifying, and adapting modeling extensions to the GRASS 4.0 programming environment. The program modules or processing extensions are collectively known as PROMAP and were developed by **Ball (1990)** to examine complex dynamic modeling as an extension of Geographical Information Systems and related technologies (e.g. resource management computer information and retrieval systems).

Spatial dynamic modeling requires algorithms and data storage that are consistent with iterative processing. The PROMAP programming operators use integer or real numbers depending on the type of operation and function being performed. Storage of integer information is in the standard GRASS format while the real number information is stored as a simple binary file. The modules that have been developed are shown in **Table 1**. The modules are compiled as contributed programs in the same manner as other GRASS functions.

In addition to the basic operations, two specialized modules have been developed for use in fire spread modeling. As an example of spatial dynamic modeling in GIS we will examine the fire simulation model known as FIREMAP (**Vasconcelos, et. al., 1990; Ball and Guertin, 1990**).

FIREMAP is based on the fire equations of **Rothermal (1972)** and the BEHAVE program of **Andrews (1986)**. In producing a fire growth simulation the GIS is used to develop the base maps for fuels, slope, aspect, moisture and other fire parameters. Once the base layers are constructed, the PROMAP programming modules called "Sbehave" and "Sfire" are used to produce the simulation. The first module calculates the fire characteristics for all the cells in the data base. The Sbehave module produces two files as standard output. These files represent the rate of spread, the midflame wind speed, and the direction of maximum spread. The second and third parameters as combined into a single file. The files, "hros" and "windms" respectively, are used as the input to the fire modules.

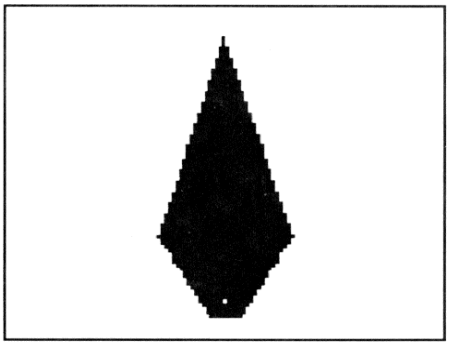

Figure 1

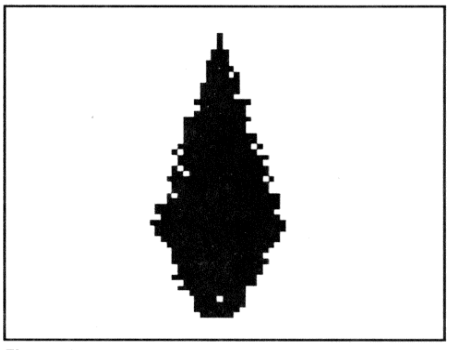

Figure 2

Stream Restoration *(Continued from page 15)*

and hydrologic principles (Jackson and Van Haveren, 1984). This scheme is based on the premise that a channel in coarse alluvium is considered stable if design discharges and sediment loads can be carried without causing excess bank or bed erosion or deposition. This design, with modifications for subarctic conditions, was the basis for the 1991 pilot study.

An important aspect of this channel design scheme is consideration of the process of adjustment from the initial stable channel geometry in noncohesive materials to the final regime geometry. When streamflow or sediment loading rates increase, channel widening may be expected to occur.

However, channel depth decreases with an increase in sediment loading rates. When conditions that have caused channel impacts such as widening and depth reduction begin to abate, and riparian zone revegetation begins to occur, the channel should begin to adjust itself toward a narrower, deeper geometry. Therefore, any design should plan for and incorporate this modification.

The central channel design is based upon a capacity to transport the bankfull flow of more stable reaches in the same setting. Incipient bed instability should be attained at bankfull flow, allowing upstream bed material to pass and enabling channel geometry to adjust to bank revegetation. Bankfull discharge may be considered as the 1.5-year flood.

Floodplain design objectives include a capacity for the 100-year flood. With this parameter, the floodplain should act to dissipate high water flow energy while encouraging deposition of sediments for vegetation habitat enhancement. Ideally, the floodplain design should minimize earthwork and expense while approximating, as closely as possible, a natural or stable channel flood plain condition.

Once the design parameters for channel banks and floodplains were calculated, preparation work began on the ground along a 1400′ reach. Design elevations and distances were surveyed and staked, and a crawler-dozer, front-loader, and dump truck were employed to move the ground to the desired configuration. Where the stream channel was incised, the adjacent floodplain was cut back and lowered, with the excess material graded into the slope of the valley wall. Additionally, flat braided sections were filled in, encouraging a single channel. The floodplain surface was roughened by the dozer to retard erosion and capture fines.

Undisturbed floodplains in the Kantishna area are stabilized by riparian vegetation (primarily feltleaf willow (*Salix alaxsensis*) and alder (*Alnus crispa*), which anchors the substrate and decreases the velocity of floodwaters. The drop in water velocity accelerates the deposition of sediment and organic debris.

Several methods are being tested to temporarily stabilize the new floodplains until natural revegetation becomes adequate, which is predicted to take 5 to 10 years. Methods include well-anchored brush bars 15 to 20 feet long, oriented perpendicular to the channel. Bars are constructed of alder branches tied in bundles, partially buried and spaced at intervals of three channel widths. Streambank plantings of feltleaf willow cuttings and alder seedlings also have been established.

A comprehensive hydrologic monitoring effort was enacted, the objective being to evaluate the current "health" and recovery status of Glen Creek following channel and floodplain reclamation. Cross-sections were established for sampling selected parameters above, in, and below the reclaimed reach. Parameters sampled include suspended sediment, stream chemistry, and biological communities. Stream discharge measurements were made at all sampling times. Effects of stabilization techniques will be evaluated by monitoring floodplain morphology, sediment deposition, and natural revegetation on floodplains with and without stabilization.

Future Studies

In order properly to evaluate the effects of an active reclamation effort on a disurbed stream channel and floodplain, a much longer reach of stream channel is needed. Funding from NPS-WRD (Water Resources Division) will allow an adjoining 3200′ reach to be included in the study. Additional techniques will be tested on this section during the 1992 season, including some channel reconstruction. This study, combined with the 1991 pilot study, will serve as a demonstration project for other mined stream reclamation efforts in DENA and other areas of Alaska.

Karle is Hydraulic Engineer at Denali NP; Dr. Densmore is Denali Park Ecologist.

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Jackson, W.L. and B.P. Van Haveren. 1984. Design for a stable channel in coarse alluvium for riparian zone restoration. Water Resources Bulletin, American Water Resources Assn. 29(5):695-703.

The fire module defaults to a 3x3 window to determine what cells have the potential to be ignited. The algorithm takes into account vector information (aspects as whether the fire will be entering as a head fire or as a flanking or backing fire). As a consequence, the modeled fire spread is a result of fire characteristics as well as terrain and fuel heterogeneity. **Figure 1** illustrates the results of fire growth over uniform terrain and with uniform fuels for a wind driven fire. **Figure 2** illustrates the results with the use of uniformly random fuel moistures.

Testing of LD_{50} GIS Model

As part of the field evaluation and testing program for the FIREMAP simulation we have been working with a Grand Canyon data base. The availability of fire data and statistics from Point Sublime, Grand Canyon, as modeled by **Kunzmann, Bennett, and Ball (1990)** for a Species Lethal Diameter Class Fire Mortality Model (at 50% class mortality; **Figure 3**), as abbreviated LD_{50}, has provided a starting point to estimate ecological fire effects for 4 species of coniferous trees.

The LD_{50} data provides a quantitative data for fire intensity vs. species diameter for the fuel models on the North Rim of Grand Canyon National Park. Running simulations based on average meteorologic data and information collected by Kunzmann and Bennett, we have begun to examine how well the model relates to the measured conditions. Testing is still in the preliminary stages and we have been examining other potential sites for subsequent testing.

Discussion

In general, higher resolution DEM data, georeferenced site data and maps are requirements for spatial dynamic modeling. For example, the use of 200 foot contours does not provide sufficient resolution for most fire spread models. A Grand Canyon data set using available 200 foot contour data makes the North and South Rims appear very flat thereby reducing the effect of landscape factors which can play a major role in fire spread. Furthermore, the specific type of DEM algorithm utilized can significantly effect the results obtained even in the simplest viewshed analyses (**Christofferson, Potter, Guertin, & Kunzmann, 1991**). Greater emphasis must be placed on obtaining better georeferenced information for site data and historical fire patterns. Better georeferenced site and DEM data are required to test modeling assumptions and computer algorithms. Quantitative evaluation and validation of site information are prerequisites to assessing the precision and accuracy of GIS computer models.

Directly related to fire, there are problems that need to be addressed in some of the current analytical programs being used such as the BEHAVE system. BEHAVE was not intended for use in computer simulations and therefore algorithms need to be adjusted to make them more useful in a GIS environment. At the University of Arizona, modeling adjustments are being tested and enhanced wind profile and fuel models are being incorporated into the GIS GRASS environment.

Other resource applications of spatial dynamic modeling include: watershed problems such as erosion, sediment transport, and water quality. The analysis of traffic patterns, usage levels and other temporal problems are also possibilities for this type of modeling. For more information concerning PROMAP contact George Ball at the School of Renewable Natural Resources at the University of Arizona or Mike Kunzmann at the CPSU/UA.

Ball is a Research Specialist on the U/AZ faculty; Kunzmann is an Ecologist and Bennett a Research Scientist at the U/AZ Cooperative Park Studies Unit.

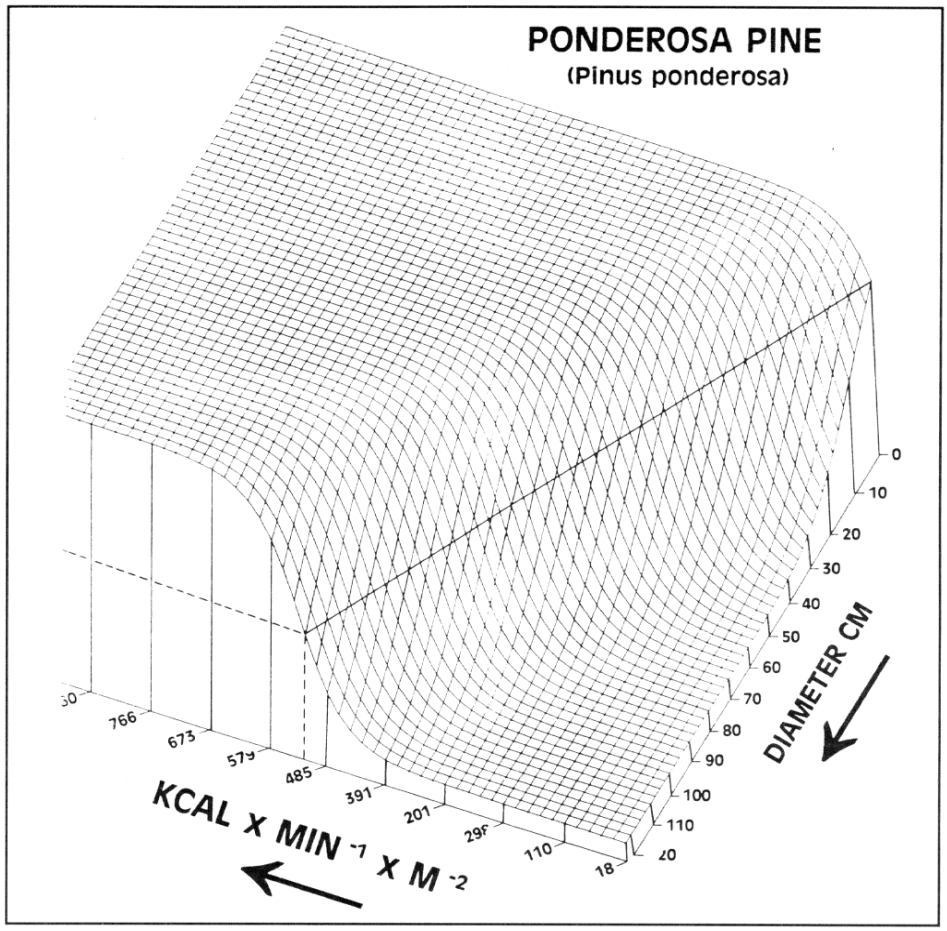

Figure 3. *LD_{50} Mortality Probability*

Table 1. *PROMAP - GRASS Operators*

Operator	Function
Sbool	Performs boolean operations
Scode	Reclassify values on a map
Sdrain	Find drainage paths over a terrain surface
Smath	Perform mathematical calculations using maps as input
Smm	Minimize or maximize values on a series of maps
Spoint	Change values at specific locations or block areas
Sscan	Analyze the attributes of a neighborhood
Sslice	Create interval map from continuous data
Ssprd	Propagate values from a source
Sterr	Calculate slope, aspect and ridge lines from DEM
Sview	Performs viewshed analysis
Sbehave	Specialized operator for calculating fire characteristics
Sfire	Specialized operator for simulating fire growth

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Andrews, Patricia L. (1986). BEHAVE: Fire behavior prediction and fuel modeling system - BURN subsystem, part 1. USDA Forest Service, General Technical Report, INT-194, Intermountain Forest and Range Experiment Station.

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Vasconcelos, M.J.; D.P. Guertin and M.J. Zwolinski (1990). "FIREMAP: simulation of fire behavior with a geographic information system. In Effect of Fire Management of Southwestern Natural Resources (Krammes, J.S. ed.), p. 217-221. General Technical Report RM-191, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Note: The PROMAP code is listed as a SUN CATALYST product and is available free of charge to interested researchers. It is a research grade programming tool and should be used as such. The use of PROMAP is encouraged for the development of end user applications. It has been developed and runs on SUN SPARCstations and should run on all UNIX based computer platforms. There is no display capability built into this software as of this date and PROMAP documentation is preliminary.

publications

After the Ice Age: The Return of Life to Glaciated North America, by E. C. Pielou (1991 University of Chicago Press, 366 pp. ISBN 0-226-66811-8).

Less than 20,000 years ago nearly all of Canada and the northern tier of the U.S. was covered by an expanse of ice about the size of Antarctica. Pielou's masterful synthesis of geological, palynological, and biogeographical information provides a vivid account of the transformation of the continent that occurred as the ice melted. She also provides useful instruction about the limitations of different sources of information (e.g. pollen diagrams) and clearly presents opposing arguments on several controversial scientific issues – whether or not a "mammoth steppe" occupied Beringia, the time and route of colonization of the continent by humans, and the much discussed possible role of man in the extinctions of large mammals. The book is natural history at its finest, and should be required reading for NPS scientists and naturalists.

Doug Houston, Wildlife Ecologist
Olympic NP, Port Angeles, WA 98362

* * *

Our Changing Landscape: Indiana Dunes National Lakeshore is the title of U.S. Geological Survey Circular 1085, edited by Catherine Hill, Barbara Ryan and Bonnie McGregor for the USGS and Marie Rust for the National Park Service.

Following a joint Foreword by USGS Director Dallas Peck and NPS Director James Ridenour are 45 spectacular, color-drenched pages – a photographic essay on some of the environmental challenges facing Indiana Dunes. "The earth-science issues facing Indiana Dunes mirror national issues faced by other parks and public lands," the Foreword states, and then continues wtih a quote from Francis Bacon: "Nature, to be commanded, must be obeyed."

The issues described in this essay include global change, land use, wetlands, coastal erosion, and contamination. The publication is free on application to the Books and Open-File Reports Section, USGS, Federal Center, Box 25425, Denver, CO 80225.

* * *

A Heritage of Fishing: The National Park Service Recreational Fisheries Program, edited by Lissa Fox with graphics by Mark Stephen Hall, is a handsome, 20-page, full color publication describing NPS participation within a National Recreation Fisheries Policy framework. In June 2988, the NPS and more than 60 federal, state, and private organizations signed such a policy, to provide long-term common goals for managing the nation's recreational fisheries. The booklet describes many of the recreational opportunities involving fishery resources currently available in park units, and oautlines future actions to improve and enhance the Service's fishery resources.

Copies are available from the NPS Wildlife and Vegetation Division, PO Box 37127 MS 490, Washington, DC 20013-7127

* * *

State of the World: 1992, the annual report of the Worldwatch Institute on progress toward a sustainable society, is out and being met with even more than the usual enthusiastic reviews. The ***Wall Street Journal*** describes it as "a runaway bestseller." With worldwide sales topping 300,000 and available in 26 languages, this book is used by policymakers at all levels of government and by corporate managers and planners all over the world. It is required reading in more than 1,300 courses in nearly 700 U.S. colleges and universities. ***Science*** magazine observes: "It points us wisely ... toward a much stronger and better-supported interdisciplinary monitoring of indicators that bear on the chances for progressing toward a sustainable society."

Paperback editions are $10.95 for one, $7.95 for 2-4 copies, and $5.95 for 5 or more copies, from Worldwatch Institute, 1776 Massachusetts Ave., N.W., Washington, DC 20036-1904.

* * *

From Jill Baron, Research Ecologist with the NPS Water Resources Lab at Colorado State University in Fort Collins, comes word of a new book, presenting the Loch Vale Watershed study.

Biogeochemistry of Subalpine Ecosystem: Loch Vale Watershed, 1991/approx. 240 pp., 90 illus./ Hardcover $89.00/ISBN 0-387-96705-1 (Ecological Studies, Vol. 90).

Published by Springer-Verlag and edited by Dr. Baron, with a Foreword by Jerry Franklin, this study increases understanding of natural biogeochemical pathways and the effects of acidic deposition in the alpine and subalpine environment of Rocky Mountain NP. The study characterizes precipitation, bedrock, soils, lakes and streams, aquatic organisms, and woody vegetation. It attempts to quantify major elemental and pollutant flux, and identifies sources, sinks, and controls of important ions.

Among the topics addressed in this synthesis are sources and seasonal variations in acidic deposition, buffering of surface waters through soil processes, geochemical mass balance, the chemical composition of surface waters, nutrient and growth dynamics of old-growth spruce-fir forests, and some methodological considerations.

A major objective of the Loch Vale Watershed study was to show the validity of ecosystem analysis as a resource management tool that allows quantitative assessment of the effects of human activities on natural systems. This book then is of interest both to researchers studying these processes and to managers concerned with potential loss of ecological integrity.

The book may be ordered from Springer-Verlag New York, Inc., P.O. Box 2485, Secaucus, NJ 07096-9812, add $2.50 for postage and handling; or call toll-free 1-800-SPRINGER between 8:30 am and 4:30 pm Eastern Time, weekdays.

* * *

From Doug Wilcox, now with the USFWS National Fisheries Research Center-Great Lakes, at Ann Arbor, MI, comes a reprint from the ***Canadian Journal of Botany*** (Vol. 69:1542-1551). The article, co-authored with James Meeker of the U/WI botany department, is titled "Disturbance effects on aquatic vegetation in regulated and unregulated lakes in northern Minnesota," and represents some results of the work Wilcox did while he was on the staff of Indiana Dunes National Lakeshore.

* * *

Park Paleontology is the title of a newsletter that first appeared in January 1991, edited by Vincent L. Santucci (now paleontologist/curator at Petrified Forest NP) and aimed at furnishing paleontological information to the many NPS units with such resources. Santucci explains that paleontological resource management, protection, and interpretation strategies have developed rapidly over the last decade, with only a handful of paleontologists employed by the NPS to assist the many parks that lack staff trained in paleontology and in developing fossil management strategies.

Five issues later, ***Park Paleontology*** now is a quarterly, serving 70 NPS units with recognized fossil resources. Overwhelming interest has widened the focus to include any federal, state, or other agency that manages, protects, and interprets paleontological resources, and whose personnel are interested in sharing ideas and techniques for management of fossils on public lands.

Scope of the newsletter includes (1) announcement of new fossil discoveries; (2) description of paleontological research and management of this research at NPS and other sites; (3) tools and techniques for interpretation of fossils and related topics such as geologic time, evolution, etc.; (4) new exhibits or displays related to fossils; (5) ideas related to use of professional paleontologists for training park staff, providing curatorial assistance, identifying sensitive resource areas, etc.; (6) curatorial techniques related to fossil collections, and (7) law enforcement concerns regarding protection from vandals or theft of paleontological resources. Contact: Vincent Santucci, P.O. Box 2266, Petrified Forest, AZ 86028.

* * *

The Fire Research Institute, PO Box 946, Roslyn, WA 98941-0946, publisher of the ***International Journal of Wildland Fire, The International Bibliography of Wildland Fire***, and ***The International Directory of Wildland Fire***, is beginning a new publication – ***Bulletin of the Fire Research Institute***. The bulletin will list, on a monthly basis, any new journal and newsletter articles on the subject of wildland fire, together with an abstract. For more information, call (509) 649-2940; Jason Greenlee, Director.

* * *

Jurassic Park, by Michael Crichton. Ballantine Books, New York. 1990.

Ian Malcolm, one of the characters in *Jurassic Park*, says: "Discovery is always a rape of the natural world. Always."

My mind wandered a bit from the story when I read that line on page 284. My mind's eye focused on Columbus and others who conducted trips of "discovery." I asked myself what are the real cultural, social, and biological ramifications of these expeditions? ***Jurassic Park*** is not a story about an expedition, but it does present a set of fictional conditions that could be profitably noted by many, especially those managing natural ecosystems.

Power and influence have driven some mighty events, and these driving forces are behind the coming-into-existence of the fictional Jurassic Park. In the book, money buys specific technology, knowledge, and isolated space for a park that features cloned dinosaurs.

Continued on page 19

notes from abroad

By Rick Smith
NPS Southwest Region Associate Director

The call from Rob Milne, Chief of the Office of International Affairs, was unexpected.

"Is it true that you and Kathy are going to Honduras on annual leave?" When I reponded affirmatively, he countered with another question.

"Would you consider going a week earlier to follow up on Secretary Lujan's recent visit to Honduras?" He went on to relate that the Secretary had stopped in Honduras on a swing through Central America. He had promised Honduran officials that agencies under his supervision would visit the country to explore potential partnerships with Honduran conservation agencies. It would be my task, Rob explained, to examine whether there were ways the National Park Service could aid our colleagues in Honduras. Since any trip to Latin America is inevitably interesting, I eagerly accepted. I was not disappointed.

By developed country standards, Honduras is relatively poor. Slightly larger than Tennessee, it shares boundaries with Guatemala, El Salvador, and Nicaragua. The 5+ million people enjoy a subtropical climate in the lowlands and a temperate one in the mountains. The country is mostly mountainous in the interior, with narrow costal plains. Agriculture is the most important sector of the economy, accounting for nearly 30 percent of the GNP, employing 62 percent of the labor force, and producing two-thirds of the exports. As with many developing nations, Honduras faces the issues of a high population growth rate, estimated to be 3.1 percent, a high unemployment rate, a lack of basic services, a large public sector, and an over-dependence on exports such as coffee and bananas, which are subject to sharp price fluctuations.

During my official stay in Honduras, I visited 4 protected areas and added a fifth while on annual leave. What I saw was absolutely amazing. Our first stop was Copan, a World Heritage Site. Copan is nothing short of breath-taking. Nestled in a fertile valley, the site is testimony to the genius of the Mayans. Archeologists have studied the site in detail and much has been excavated and stabilized. These experts speculate that as many as 30,000 people may have lived there in 800 AD. If true, this would make Copan one of the largest urban centers in the world at that time, certainly larger than anything in Europe. Perhaps only urban centers in Asia would have been larger.

In a story that would not be unfamiliar to Southwestern archeologists, the collapase of Copan in 900 AD is thought to have been the result of an expansion by the urban community into the rich agricultural areas, moving the agricultural base of the city up into the marginal lands on the nearby hillsides. Since the community was no longer self sufficient, the rulers had to share power with others who could supply the population with the necessary food. This power sharing led to the diminishment of the rulers'authority and eventually to the abandonment of Copan. The site boasts a visitor center, an arts and crafts shop, a small restaurant, bilingual guides, and an entrance gate to control visitation. As the most famous tourist attraction in Honduras, it is well maintained, administered by the Honduran Institute of Anthropology and History, a semi-autonomous government organization.

Our next stop was at Cuzuco NP. We left early one morning, climbing straight up 2,000 meters out of San Pedro Sula on a dirt road. Even with four wheel drive, we managed to get stuck in one place. The climb passes through several life zones and gives a fascinating look at the changes civilization is bringing, not only to the people, but also the environment. It is almost like the rite of passage ones goes through going from Key West to Fort Jefferson National Monument. The visitor begins in San Pedro Sula, the entrepreneurial capital of the country, an example of our 20th century civilization, climbs out of the city, leaving the 20th century behind, and passes through small villages and clusters of huts, most of which do not even have electricity.

At the village of Buenos Aires, I would recommend that all vehicles be required to stop and that the tourist make the rest of the trip, some 4-5 kilometers, by horse or mule. The villagers in Buenos Aires should be given the opportunity to offer modest services such as guiding, mule rental, food, etc. This would make them supporters of the park because they would have an economic interest in its preservation. The passage from the 20th century would end in Cuzuco NP, a slice of what Honduras looked like prior to arrival of the Spanish in the 16th century.

Cuzuco is a smallish rainforest park, some 10,000 ha. The park's only infrastructure currently is a small visitor contact station, without electricity. Plans for the park call for construction of small huts where visitors could stay overnight for a modest fee. What they would see while there is the astonishing biodiversity. During the time I wandered in the park, it occurred to me that I could not name one living thing.

The Honduran Forest Service administers the park and has in place one unique management strategy I believe could be profitably adopted by the NPS. In the middle of the park, they have established what they call a *zona intocable*, an untouchable zone. No one is allowed to go there, no visitors, no administrators, and no scientists. The concept is that it will serve as a control point to measure the pace of change in the rest of the park caused by visitation. Wouldn't it be great if we could establish such zones in some of our great wilderness parks in Alaska or in the West?

From Cuzuco, we went on to La Fortaleza de San Fernando de Omoa, an 18th century Spanish fort on the northern coast. The Spanish constructed the fort to protect a nearby harbor. The Hondurans were involved in an historic preservation project at the fort, and their efforts reminded me of many of the preservation problems at our coastal parks.

Our final stop was the Lancetilla Botanical Gardens. Although threatened by nearby development, the Gardens contain a representative sample of the native species of Honduras and a demonstration of the exotic species that have been brought to the country over the years by agricultural or business experts. There is the thought that the gardens represent a kind of genetic warehouse for the native species of the country. If any type of restoration ecology ever became feasible, the gardens would serve as seed sources.

The trip provided a fascinating look at the conservation issues facing a Central American country. All the official representatives with whom I met were appreciative of the interest Secretary Lujan is demonstrating in Honduras. They hope for close cooperation between the bureaus of the Department and the Honduran government. I see several areas in which I believe the NPS could assist. I propose that we consider establishing a system of "sister parks" for some of the protected areas within Honduras. The staff in the sister parks could provide technical advice, exchange information, and provide an avenue for our visitors to get to know the parks of another country. Any one of our coastal forts, for instance, faces many of the same issues that face the staff at Omoa. Our archeological parks share issues with Copan. Natural areas have much in common with Cuzuco. I remember that the Peace Corps used to administer a similar program with schools, called, as I recall, the School Partnership Program. Maybe we could get the Peace Corps to establish a similar program with parks.

Also, we could provide assistance in the country's environmental education program. It is absolutely certain that the success of any conservation efforts in Honduras will revolve around changing peoples' attitudes toward unchecked exploitation of natural resources.

There also are possibilities for technical advice and assistance in areas such as interpretation, protection, and resources management. I saw, as an example, several things during our visit to the restoration project at the fort that bothered me. I'm sure a good historic architect could make useful suggestions. Our archeologists could assist in establishing processes for field investigations and data collection and recording. Aside from the guides at Copan, I saw no attempt to interpret park resources to any visitors who might show up at a protected area. Finally, there is a critical need for coordinated planning for park areas. I reviewed, for example, the goals and objectives for Cuzuco. I did not feel there was enough emphasis on consulting with local people or the other agencies that will have to cooperate if the park is ever going to be open for visitation.

Publications *(Cont. from p.19)*

The project, with its exotic cast of prehistoric characters, is held close to the power brokers' chests. Those who provide general knowledge about the animals and their behavior are kept in the dark as much as possible.

A meeting of the power brokers and those knowledgeable about the animals, held at the island park, is the setting for events that demonstrate the impossibility of "control" on the part of the perpetrators. Once natural events are set in motion – even in the most unnatural ways – the question rapidly degenerates from one of control to one of mere survival.

Ian Malcolm and Dr. Grant are characters who grab and hold your interest as the exciting plot unwinds. Malcolm's intellect and Grant's broad knowledge are consistent reminders that all societies need a healthy mix of raw intelligence and educated thought as we continue our search for understanding our world.

If you are a regular reader of world and environmental issues, this book will help you focus beyond the specifics. We are part of a larger scheme – one which simply may not be comprehensible, but one which is not necessarily totally chaotic.

To quote Ian Malcolm: "It's a matter of what you think you can accomplish. When the hunter goes out in the rain forest to seek food for his family, does he expect to control nature? No. He imagines that nature is beyond him. Beyond his understanding. Beyond his control. Maybe he prays to nature, to the fertility of the forest that provides him. He prays because he knows he doesn't control it. He's at the mercy of it ... Your power are much less than your dreams of reason would have you believe."

R.J. Valen, Chief of Interpretation
Guadalupe Mountains National Park

regional highlights

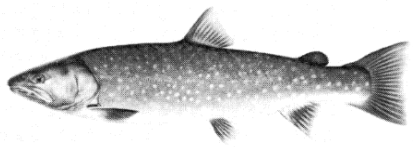
Editor's Note: *We* ***love*** *Regional Highlights! But eventually we could fill the entire issue with them. Because our space is limited, we must ask that all Regional Highlights be routed through the Regional Chief Scientist (or the designated purveyor of Highlights for the Region) and that he/she be responsible for making them as brief as possible (while still getting the messages across) and RANK them in the order of importance, in case we still must cut. Thank you so* ***very*** *much.*

Pacific Northwest

Bull trout, once found in most major river systems in the Pacific Northwest and Canada, have lost ground (or water) over the past 30 years, and many local extinctions have occurred. The Klamath River Basin, Oregon, populations are genetically distinct from other Pacific Northwest populations and are now restricted to cold headwater streams. Habitat degradation and introduction of non-native species are believed the primary causes for the recent decline. Bull trout have been listed as a candidate species under the Endangered Species Act by the USFWS, and as sensitive species by the State of Oregon.

Crater Lake NP has developed a bull trout management program to remove introduced brook trout from Sun Creek in the park, build a barrier to prevent re-invasion, and re-establish a self-sustaining population of bull trout in Sun Creek to the park boundary. No management action will be taken until an Environmental Assessment by an interagency team of experts is produced and made available for public comment.

Mark Buktenica, the park's aquatic biologist, will furnish ***Park Science*** with an article on the management program in a future issue.



Bull Trout *Reproduced with permission of J. Tomelleri*

Southeast Region

Dr. Stephen V. Cofer-Shabica, oceanographer, has been named Director of the NPS/CPSU at the University of Georgia following the departure of Dr. Susan Bratton.

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Skip Snow, Resource Management Specialist at Everglades NP, participated in a USFWS-sponsored technical workshop on the Florida manatee population biology in Gainesville Feb. 4-7, 1992. Seventy participants provided information on manatee biology and ecology to an invited panel of 10 population biologists and statisticians, including such notables as Lee Eberhardt of Battelle Labs, Douglas DeMaster of NMFS, Charles Fowler of Alaska Fisheries Science Center, James Nichols of USFWS, Robert Garrott of U/WI, and Helene Marsh, dugong researcher from James Cook University, Australia.

The panel was charged with making recommendations on how to improve our knowledge of manatee mortality and survivorship, population estimation and trends, and estimates of growth rate and development of simulation models. One recommendation was to establish a Manatee Aerial Survey Working Group. Snow was selected as a member of this group. Workshop proceedings will be made available in coming months.

* * *

Everglades Resource Management Specialist Skip Snow and pilot Dave Dutcher participated in the 1991-92 Florida Statewide Synoptic Manatee Aerial Survey Jan. 17-18, 1992, by contributing aerial survey results from the park's entire coastline and mangrove zone. Conditions were near perfect and a record 1,856 manatees were counted statewide.

Within Everglades NP and the adjacent upper Florida Keys, 106 manatees were counted. Despite the high count (1,856), the true population size remains unknown, and there is no reason to believe that manatees are less endangered than before or that we should halt any ongoing manatee conservation strategies. The record numbers of documented deaths in recent years remain a major impediment to the species' recovery. More manatees died from human-related causes (68) in 1991 than ever before. Likewise, more small ("perinatal") calves died (53) than ever. Statewide, continuing levels of habitat loss and degradation, as well as possible water pollution, also are serious ongoing concerns.

* * *

The CPSU at U/TN is expanding. A search is underway for a second research ecologist, to join Stephen Nodvin, who has been the only NPS scientist on staff since 1988. John Peine also has been added to the staff as Research Social Scientist.

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Nodvin has submitted two proposals to the Cooperative States Research Service through U/TN toward developing new research in the Great Smoky Mountains NP. He worked with Dr. Helga Van Miegroet of Oak Ridge National Lab (ORNL) in developing the proposal: "Nitrogen Dynamics and Nitrate Export in Southern Appalachian Forests" to evaluate the importance of ecosystem and geographic factors such as forest age and disturbance and stand elevation in regulating the export of nitrogen and other nutrients from forests at Great Smoky Mountains NP.

Nodvin also worked with Henriette Jagen, also of ORNL, in developing a proposal entitled "Multivariate Spatial and GIS Techniques to Monitor and Map Water Quality." which, if funded, would incorporate available stream quality data, new GIS data, and new multivariate techniques to develop water quality maps for streams at Great Smoky Mountains NP.

Nodvin and his CPSU staff are developing an indexed bibliography of references for Great Smoky Mountains NP – a database of primarily scientific references which now contains approximately 1800 records. Office Asst. Susan Twigg and Nodvin are indexing the references and plan to have a printed draft ready for review by this summer.

Midwest Region

In 1991, a joint NPS/Wisconsin DNR pilot study was conducted to develop methods for identifying the causes of bald eagle nest failure at Apostle Islands National Lakeshore. Data collected support the hypotheses that weather, contaminant exposure, and prey availability all may impact the Apostle NL bald eagle population. Primarily as a result of this study, a $320,000 proposal to continue and expand the project was funded by the Great Lakes Protection Fund. The expanded study will include behavioral work by NPS, Wisconsin DNR, the U/WI, and the USFWS, plus toxics analyses by MI/State/U.

* * *

A rare plant inventory at Apostle Islands NL was begun in 1991. Three endangered and 12 threatened plant species on the Wisconsin State List of Threat-

The long-awaited recovery plan for the northern spotted owl is nearing completion by an 18-member recovery team. The owl, which was listed as threatened in July 1990, has been the center of a controversy over management of Pacific Northwest forests for nearly 20 years. This medium-sized bird inhabits late successional forests, commonly referred to as "old-growth forests." These forests have enormous economic values; thus, a conflict exists between those who wish to harvest timber and those who would preserve old-growth habitats.

Northern spotted owls are found in several areas of the National Park system, however Olympic NP and Point Reyes National Seashore are especially critical to the species. The southernmost breeding pairs are located in forested areas of Point Reyes, just north of San Francisco, and they may be reproductively isolated from other pairs by residential development as well as natural grasslands.

Low and mid-elevation forests of Olympic NP provide a core of habitat for the remaining spotted owls on the Olympic Peninsula of Washington State. The park contains most of the remaining unharvested forest on the peninsula, and this population of spotted owls also may be reproductively isolated.

The recovery plan is based on a conservation strategy for the northern spotted owl which was developed in 1990 by the Interagency Scientific Committee chaired by Jack Ward Thomas. Doug Houston, Pacific Northwest Regional research biologist, played a major role in formulation of this strategy. Ed Starkey, research biologist with the NPS CPSU at Oregon State University, is a member of the recovery team.

The plan proposes that, on federal lands, suitable habitat be provided for clusters of owls distributed across their range. Although no commercial harvest would be permitted within these habitat areas, the areas would be surrounded by a matrix of forest lands on which a wide range of timber management activities would occur. However, matrix lands would have to provide habitat that would at least allow spotted owls to move freely between clusters.

Following public and agency review of the draft recovery plan and any needed revisions, the proposed final plan will be reviewed by the Secretary of the Interior. If the recovery plan is approved by the Secretary, it would provide guidance for federal agencies as they develop action plans for management of the northern spotted owl.

ened and Endangered Species were known to occur in Apostle Islands NL prior to 1991. Two additional State endangered species found in the 1991 study were *Salix cordata* and *Armoracia aquatica*, and significant new localities were discovered for *Pinquicula vulgaris* (State endangered), *Trisetum spicatum* (State threatened), and *Salix planifolia* (not listed). Unsurveyed portions of the Lakeshore will be surveyed in 1991; inventory results will include rare species locations and descriptions, habitat requirements, recommendations for protection, and monitoring protocols, plus a published flora for the Lakeshore.

* * *

The USFWS has published a proposed rule in the ***Federal Register*** to list the Karner blue butterfly (*Lycaeides melissa samuelis*) as an endangered species. Its habitat is characterized by the presence of wild lupine (*Lupinus perennis*,) the only known larval host food plant and thus closely tied to the butterfly's ecology and distribution. Habitat is typically grassy openings within dry sandy pine/oak barrens or oak savannas. Periodic disturbance is required to maintain open areas supporting lupine. A 1990 survey by Indiana DNR searched 24 sites with potential Karner habitat; six were found to be inhabited by the Karner blue butterfly and are within Indiana Dunes NL.

* * *

Two NPS scientists, Walter Loope of Pictured Rocks and Lisa Thomas of Wilson's Creek, were visiting lecturers at U/WI, Madison, courtesy of the Great Lakes CPSU. Loope visited the Geography and Geology and Geophysics and lectured on fire ecology in northern hardwoods. Thomas visited in the Dept. of Landscape Architecture and presented a seminar on prairie restoration.

Whale Stranding at Everglades NP

On the afternoon of Jan. 30, 1992, an Everglades NP visitor reported a group of whales, later identified as short-finned pilot whales (*Globicephala macrorhyncha*) attempting to strand on the remote wilderness beach of Northwest Cape. Regional, state, and local marine mammal stranding authorities were contacted for advice.

Due to the remoteness of the area, limited care facilities and a poor rehabilitation record for the species, a rescue and removal effort was not undertaken. Park Rangers responded to find 11 pilot whales stranded with one dead and three more swimming slowly offshore. The rangers attempted to refloat the whales and after a short time all were moving about in deeper water offshore. Efforts to save stranding pilot whales often prove futile because the animals restrand immediately at the same location or some time later several hundred kilometers away.

The following morning park staff conducted boat and aerial surveys of adjacent coastline, but no pilot whales were observed. Later that morning, biologists from the Florida DNR and the National Marine Fisheries Service were delivered to the site by Florida Marine Patrol helicopter to conduct a field necropsy. The animal was a 332 cm female with congested lungs and stomach ulcers. Cause of death was bacterial pneumonia.

Park staff later learned that on the morning of January 30, local fishermen had observed as many as 26 whales attempting to strand at the same location, with an undetermined number swimming in the surf around their boats. The fishermen had attempted to refloat the whales while trying to radio for assistance. Approximately a week later, three pilot whales were found stranded, two dead and one alive, south of Naples, FL, well to the north of Northwest Cape.

Pilot whale strandings, often involving 100 or more animals, are common in North America, for reasons still not known. The largest recorded U.S. stranding occurred in 1933 and involved over 200 pilot whales in what is now Everglades NP, from East Cape Sable to near Flamingo. The recent event has park staff talking with marine biologists and reviewing just what kind of intervention is appropriate for a national park.

Air Quality Division

Kathy Tonnessen, Director of the NPS Air Quality Division's Biological Effects Program, was co-author with Mark Williams (U/CO) of a paper on "Hydrologic and Hydrochemical Lessons for the Front Range: An Overview of the Emerald Lake Watershed Study," presented at the Front Range American Geophysical Union meeting in February. The authors discussed results of an intensive watershed investigation at a high elevation watershed in Sequoia NP, with emphasis on the importance of studying snowfall and snowmelt to assess the potential for lake and stream acidification. This work is being continued under NASA sponsorship as part of the Earth Observing System (EOS), and will include monitoring of high elevation sites in the Sierra Nevada, the Rockies, and mountain sites in China and Austria.

* * *

The Division recently published the proceedings of a workshop co-sponsored with the Water Resources Division on Acid Rain and Air Pollution in Desert Park Areas, by D. Mangis, J. Baron, and K. Stolte (Tech. Rpt NPS/NRAQD/NRTR-91/02). The volume includes 12 papers presented at the conference that address the nature of air pollution and deposition in the West and the potential for damage to aquatic and terrestrial ecosystems and cultural resources. Copies may be had from the Tech. Info. Center in Denver, (303) 969-2130. The Division is involved in a review of air pollution issues in Saguaro NM. Tonnie Maniero (Policy, Planning, and Permit Review Branch) is organizing the review of the biological effects research program sponsored by the AQD since 1984. The review will evaluate the levels of ambient air pollutants and deposition in the monument and potential impacts on vegetation.

* * *

Deborah Mangis, biologist with the Research Branch, attended a global change and air pollution research coordination meeting organized by the USFS, Southern Global Change Program, Raleigh, NC. Representatives from federal agencies, industry groups, and universities presented information on ecosystem studies in the southern U.S., emphasizing potential impacts of oxidants, acid deposition, air toxics, and global change on forest ecosystems. Attendees discusssed sharing of research sites and funding – discussions that were continued at the Forum on Air Quality Management in the Southern Appalachians in March at Gatlinburg, TN.

Southwest Region

Dr. Samuel Kunkle, formerly with the USFS in Washington, DC, has accepted the post of Regional Chief Scientist, relieving Dr. Milford Fletcher, former chief scientist, to lead the new CPSU at U/NM, Albuquerque. Prior to his USFS assignment, Kunkle for five years worked for NPS in the Fort Collins-based Water Resources Division. His field is tropical forestry.

* * *

Robert Krumenaker, formerly a resource management specialist at Isle Royale, is now a physical scientist in the Southwest Region, replacing Keith Yarborough who, in turn, has become the first park scientist to be stationed at Big Bend NP. Yarborough also maintains offices (two days a week) at Sul Ross University in nearby Alpine, TX.

* * *

Jerry McCrae, formerly NPS-IPM coordinator in Washington, DC, is now leader of IPM in the Region, replacing Gerry Hoddenbach, who is on temporary leave to be with his wife, Lois, who is the new safety officer at Grand Canyon NP.

Rocky Mountain Region

In October 1991, a wild horse roundup, conducted in Theodore Roosevelt NP with 2 helicopters and 12 riders, captured 93 of the park's 114 wild horses. Of these, 58 wer sold at auction, the remainder were released into the park as part of a historic demonstration herd. Blood was taken from 77 animals for genetic testing at U/KY. This reduction, the first since 1986, received wide publicity due to claims that park horses are a distinct breed, descended from Sitting Bull's ponies (a premise disputed by area ranchers).

Last year, a bill to make this so called "Nokata Horse" the state horse failed in the ND legislature. Attempts to halt the roundup through the state's Congressional delegation and governor's office were unsuccessful. Representatives from the Human Societies of both the U.S. and ND were pressent. The culling eliminated animals introduced in recent years with the goal of preserving traditional bloodlines. Genetic analysis combined with recent range use and carrying capacity studies of the park herd will establish a minimum herd size.

* * *

Devils Tower NM completed an extensive exotic plant mapping project in 1991. The Braun-Blanquet species abundance mapping method was used to map 53 of the 55 exotic species known from the Monument. Results will be used as a baseline to monitor changes in distribution and abundance of exotic plant species over time, to evaluate effectiveness of control methods, and to determine the best locations to concentrate control actions.

* * *

Last fall, Mesa Verde NP experimented with a magnetometer to locate faults, dikes, and remnants of large archeological surface sites. The magnetometer was

Continued on page 22

made available through the USGS for two months of field work by Dr. Mary Griffiths. The device detects local differences in the earth's magnetic field, brought about by the presence of iron rich minerals in intrusions, iron in solution, or iron in rocks (as in the base of archeological sites). In Mesa Verde, faults and dikes are related to localized unusual vegetation types, water outcrops, and interesting terrain features.

* * *

Because of the difficulty of funding small-scale, high priority, hands-on natural resource management projects from park base (especially for medium and small size parks), a regional program called PRAM (for Preservation, Restoration, and Mitigation) was started in FY 91. Of 74 proposals submitted for FY 91 funding, 23 projects ranging from $1,200 to $10,000, received a total of about $150,000.

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Responsibilities for the region-wide competitive research program is being shifted from U/WY to the Regional Office, at least until pending recommendations of the National Academy of Sciences are circulated and incorporated into the NPS science program. After almost 15 years of productive cooperative agreement with U/WY, it was concluded that the NAS recommendations might alter significantly the scope of the NPS competitive research program. Thus, any decision to advertise and award a cooperative agreement for future assistance will be delayed until the NPS response to the NAS recommendations is developed.

North Atlantic Region

John T. Tanacredi, Research Scientist and Chief of Resource Management and Compliance at Gateway NP in NYC, was a keynote speaker at a recent Colloquium on Urban Marine and Coastal Issues held at Kingsborough Community College's new Marine and Academic Center. Tanacredi's address, "Issues at the Edge," dealt with the problems of our fragile coastlines and the need for further research and information sharing.

But "more important than merely making information about coastal problems more widely known," he said, "we must cause deliberate change in human activities along our coastline, shores and estuaries ... we must apply basic research to their day-to-day operational needs." He called for a companion to Aldo Leopold's land ethic concept – a "sea ethic" which, among other things, would allow natural systems to heal themselves by limiting human-caused disturbances and cultivating an ecological conscience in our dealings with the sea.

Western Region

From the CPSU at U/AZ comes news of an article by P.S. Bennett and M.R. Kunzmann, "The Applicability of Generalized Fire Prescriptions to Burning of Madrean Evergreen Forest and Woodland" in the ***Arizona-Nevada Academy of Science Journal*** (24-25:79-84); and two technical reports:

Ruffner, G.A. and R.A. Johnson. 1991. Plant ecology and vegetation mapping at Coronado National Memorial, Cochise County, AZ, 75 p. Tech. Report #41, and

Bellantoni, E.S. and P.R. Krausman. 1991. Habitat use by desert mule deer and collared peccary in an urban environment, 39 p. Tech. Report #42.

Copies of these and a complete listing of the CPSU publications are available by calling (602) 670-6886.

* * *

Mary Ann Madej, Redwood NP geologist, has completed a 160-page report, "Analysis of Bank Erosion on the Merced River, Yosemite Valley, Yosemite NP." The work was in response to the perceived threat of severe bank erosion in the Valley. She and coauthors William Weaver and Danny Hagans measured channel widths, compared them to those surveyed by USGS in 1919, and found that not only bank erosion but net channel widening had occurred in the most severely impacted stream reaches. Channel width increases, up to double the 1919 values, were most extreme in areas with intensive levels of visitor use.

They evaluated possible causes of channel widening, including hydrologic, climatologic, and physical factors, and concluded that human trampling, destruction of riparian vegetation, and flow constriction at bridge sites were primary causes of bank erosion. Riparian restoration techniques, including aggressive revegetation efforts, biotechnical controls, and removal or modification of harmful structures, were recommended to park management.

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Redwood NP women on the Research and Resource Management staff were featured in an article by Vicki Ozaki in ***Women in natural resources.*** The special issue (Vol. 13, #1), dealt with women involved with natural and cultural work for NPS.

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Nathan L. Stephenson (Ph.D. Cornell, 1988) has been hired as a Research Ecologist at Sequoia and Kings Canyon NPs, on funds provided by the Global Change Program. He will serve as a PI on studies of forest demography and the environmental controls on species distributions and ecosystem processes. His 1990 paper, "Climatic control of vegetation distribution: the role of the water balance" published in the ***American Naturalist*** (135:649-670), already has become something of a classic.

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Recent publications from NPS Western Region scientists are:

• Stephenson, Nathan L., David J. Parsons and Thomas W. Swetnam. 1991. Restoring natural fire to the sequoia-mixed conifer forest: should intense fire play a role? This paper for the first time surfaces the idea that locally intense fires may have been important in the creation of conditions necessary for establishment of the characteristic groupings of apparently even aged giant sequoia that visitors find of such interest. The possibility has significant implications for future prescribed fire management.

• Parsons, David J. 1991. Planning for climate change in national parks and other natural areas. ***The Northwest Environmental Journal*** 7:255-269. Presents an overview of issues related to climate change of special interest to national parks. It highlights early progress made by the NPS Global Change Program.

• Parsons, David J. 1991. Preparing the Sierran parks for global issues of the 21st Century. pp. 150-155 in ***Yosemite Centennial Symposium Proceedings***. Yosemite Assn., El Portal, CA. This paper reflects the multitude of threats facing the Sierra Nevada parks in the coming years and is particularly relevant to the new approach to bioregional planning reflected in the Sierra global change research program.

* * *

The NPS was highlighted in a special 2-day symposium Feb. 7-8, 1991 at the AAAS annual meetings in Chicago. The symposium, Efficacy of Long-Term Research in U.S. National Parks, was organized by Gary Davis and Bill Halvorson of Channel Islands NP as a product of an I&M initiative to present a series of case studies on the subject. When AAAS heard about the project, they asked to feature it at their national meeting and are planning to publish the 12 papers in book format.

Arthropod Populations At 3 Golden Gate Habitats Compared

French broom, an exotic shrub, has invaded native coastal scrub and grassland communities of the Golden Gate National Recreation Area (GGNRA). This plant is aggressive and very successful, forming dense, monospecific stands, which threaten the park's natural plant diversity. A field study was conducted to compare the arthropod fauna (insects and arachnids) in three different plant communities within GGNRA: coastal scrub, gassland, and French broom.

Arthropods were sampled in pitfall traps over a period of four days in mid-July 1991, during which 16,374 arthropods were collected from 36 traps. The dominant organism in both scrub and grassland habitats was the exotic Argentine ant. Only three other species of ants were collected. It is possible that the Argentine ant has displaced the native ant fauna and thereby indirectly threatens the endangered Mission Blue butterfly, which has a symbiotic relationship with some native ant species. This situation warrants further study.

The diversity of native arthropods (calculated using the Shannon-Weiner index) was highest in scrub, followed by grassland, and finally broom. In fact, it was shown that the invasion of French broom into native plant communities decreases the diversity of native arthropods by 1/3. Most species of arthropods found in broom also are found in either scrub or grassland in substantial numbers, so removal of broom does not threaten their populations. However, other species, such as spiders, beetles, and wasps, may be directly threatened by the spread of French broom.

Areas within the park that have been invaded by French broom are undergoing restoration by removal of broom and revegetation with native species. The results of this study will provide park resource managers with baseline data that previously were unavailable and will contribute to restoration and management of native communities.

Jot Lanford and Laura Nelson
Natural Resources
GGNRA, Fort Mason, Bldg. 201
San Francisco, CA 94123

gis notes

The second Servicewide GIS Users" Conference (GIS91) was held Nov. 18-22 in Lakewood, Colo., bringing together for the first time in three years all NPS users of GIS, CAD, and automated mapping technologies. Attending were 194 Service people, representing 120 NPS units and all 10 Regions.

Jan van Wagtendonk of Yosemite NP opened the conference with a perceptive perspective on 20 years of GIS in the NPS. A poster session gave participants a chance to present their respective applications, illustrated by 54 posters from 44 NPS units. Posters included analysis of endangered species habitat, siting of park housing, use of global positioning systems, management of exotic species, monitoring of endangered species, analysis of Civil War battlegrounds, management of grazing, tracking of mining, analysis of aircraft-overflight noise, and analysis of visitation statistics, among many others.

Attendees voted Joshua Tree's poster on tortoise monitoring as Most Innovative; Yosemite won Best Looking; Colonial, Most Multi-disciplinary; and Colonial, Santa Monica Mountains, and Yosemite finished in a three-way tie for Best Use in Decision-making.

Plenary sessions featured presentations from the Information and Telecommunications and Geographic Information Systems Divisions, the Regional GIS coordinators, and 12 NPS program offices. Topics included Servicewide ADP standards; the status of hardware, software, and data in the Servicewide GIS program; GIS training; telecommunications; data issues (collection, standards, management, quality); the reorientation of the GIS Division; the status and direction of the Regional GIS programs; the current and intended use of GIS technology and sharing of GIS data by NPS program offices, and funding and staffing of GIS projects throughout the Service.

Ten technical workshops focused on Global Positioning Systems, Data Sources, Cave GIS, Position Description and Classification, Map Preparation, Electric Power, Hardware, Text Data in GRASS, Future Directions in GRASS, and Networking.

The conference provided a welcome and useful opportunity for GIS users from around the Service to share experiences and ideas, to hear about institutional and programmatic directions for the Servicewide program, and to learn about technical issues. In the three years since the last such gathering (at Luray, Va., 1988), the interest in, and use of, GIS technology has grown enormously and attendees voiced a common feeling that the conference was a valuable and timely event.

GIS93 has been set for Nov. 15-19, 1993, in Denver. See y'all there.

* * *

In a rare conjunction of events, the International Society for Photogrammetry and Remote Sensing (ISPRS), the American Society for Photogrammetry and Remote Sensing (ASPRS), the American Congress on Surveying and Mapping (ADSM), and Resource Technology 92 (RT92) will hold a joint congress and convention in Washington, DC, Aug. 3-7, marking the first time in 40 years that the ISPRS will meet in the United States.

Theme of the Congress is "Mapping and Monitoring Global Change," and between 7000 and 9000 surveyers, technicians, photogrammetrists, remote sensing and GIS specialists, educators, scientists, and engineers from more than 80 countries are expected to attend, hear, and present papers in some 30 topic areas.

For more information contact me at 303-969-2593, FTS 327-2593, or FAX 303-969-2822, or Alan Voss, TVA (615-751-5425).

Harvey Fleet, Chief
Digital Cartography
NPS GIS Division, Denver

Sierra Summit Conference Takes Region's Pulse

The environmental woes of the Sierra Nevada were laid out like entrails for the uncensored inspection of 200 scientists and natural resource managers last November at Lake Tahoe. The "physical exam," organized by California Secretary of Resources Doug Wheeler, marked the first time in history that a panel of experts convened to discuss the health of the entire mountain range – all 430 miles and 15.5 million acres. The prognosis was a solemn question mark. The exercise touched sensitive nerve endings up and down the entire spectrum of "multiple users."

A firsthand account from Dave Parsons, NPS Research Scientist at Sequoia and Kings Canyon NPs, (a Natural Environment panelist on opening day of the 3-day conference), and supplemented by accounts in the ***Sacramento Bee***, concluded that the patient is sick, its vital signs – soil, water, air, forests, and wildlife – assailed by a formidable array of threats. Ozone pollution and acid rain, mercury contamination, harmful logging and grazing practices, overdevelopment, and bureaucratic and scientific neglect were identified by the conferees as major players.

Panel findings:

- Soil is eroding from parts of the Sierra at catastrophic rates, filling water reservoirs with mud and silt. Road building, livestock grazing, logging – all contribute to the problem.
- 24-hour average ozone levels in summer at Sequoia NP exceed those in Los Angeles – home of the worst air in America.
- 8 of the Sierra's 22 amphibian species are threatened with extinction; populations of many other creatures, including songbirds, are declining.
- Fire suppression, logging, and air pollution are changing the very fabric of the Sierra forest – long regarded as one of the world's grandest assemblages of trees.

Dave Graber, Sequoia NP Research Biologist, described the threats to wildlife resulting from damage to wetland systems, emphasizing the need for more knowledge about wildlife, without which "we won't have information to manage – we won't even know when we lose them."

Parsons listed major management issues – fire suppression, timber harvest (revegetation and old-growth), grazing, air pollution, drought/pests, urban and residential sprawl, plant species and community issues, genetic and biological diversity, and future global climate change – all areas of great concern for land use management planning.

Secretary Wheeler opened the summit with a strong pitch for a coordinated, bioregional approach to conservation of the Sierran forests, lakes, rivers and wildlife. Most conferees seemed willing to follow his lead.

The region's chief federal forester, Ronald Stewart, told conferees that management of the Sierra's 20 million acres of federal forest no longer will be driven by timber targets or volumes of wood from trees sold to loggers. He predicted that wildlife and recreation interests will edge out logging as the chief objectives on California's national forests. Logging, he indicated, will be allowed where it enhances recreation or wildlife.

As ***Sacramento Bee*** reporter Tom Knudson put it, "Not since naturalist John Muir preached his mountain gospel a century ago has the Sierra Nevada seen such an outpouring of interest, concern and controversy." The crowd of "movers and shakers from all walks of mountain life: national park superintendents, university scientists, state policy-makers, timber company officials, conservationists," saw hope in the snowstorm of information, the avalanche of reports, and the willingness of those present to listen and make note of one another's viewpoints and agendas.

Global Change Update

The Service's Global Change Research Program has approved 14 new research projects in 8 biogeographic areas to complement the 14 projects commenced in FY 1991. 4 new biogeographic areas (Central Grasslands, Gulf Coast, Sonoran Desert, and South Florida) and a new thematic initiative (coral reefs) join the 6 areas with ongoing work (Colorado Rockies, Glacier NP Area, Olympic Peninsula, Ozark Highlands, Southern and Central Sierra Nevada, and Western Great Lakes) to enhance the list of areas with approved proposals.

Specific projects slated to begin this year include research on holocene paleoenvironments in Western Great Lakes parks, effects of global change on Colorado Rockies vegetation, projecting climate and vegetation change for the Central Grasslands, and dynamics of the Southwest Florida mangrove/marsh fringe belt.

The Global Change Research Program has progressed greatly toward its goal of being a complete, well-integrated program. The newly approved projects fill many geographical and topical gaps in the initiative. As program funding increases, we will commence research in more of the 20 included biogeographic areas, further increasing our understanding of global change, and enhancing our ability to generate results useful for resource management.

The program's new booklet, "Global Change Research in U.S. National Parks," provides an overview of the Service's program, as well as thumbnail sketches of the areas in which we're currently pursuing, or planning to pursue, research. To obtain a copy, contact Dr. Peter L. Comanor, Global Change Program Coordinator, WASO Wildlife and Vegetation Division, P.O. Box 37127, Washington, DC 20013-7127.

information crossfile

For more than a decade, researchers have considered the last major change in the Earth's magnetic field to have occurred 730,000 years ago – between the Brunhes and Matuyama geomagnetic periods. But recent experiments by Geophysicist Michael McWilliams of Stanford University, using the argon-argon technique, suggest that this transition occurred 50,000 years earlier ... causing changes in the rock-dating results reached on the basis of the 730,000 year yardstick. McWilliams used the argon-argon technique, a variation of the standard potassium-argon dating method, to arrive at the 780,000-year figure as the interval between the Brunhes-Matuyama transition and the present. His finding confirms results reported last year by oceanographers who redated the transition by counting the number of Earth's orbital oscillations in ocean sediments. ***Science News*** reports (Vol. 141, p. 14) that redating the Brunhes-Matuyama transition eliminates some of the problems faced by scientists studying the San Andreas fault. The new yardstick eliminates discrepancies between their precise measurements across the fault that suggest the Pacific plate moves past North America at a rate of 48mm per year and the 51mm-per-year speed arrived at by way of estimates based on magnetic lineations in the ocean.

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Mt. Pinatubo's volcanic cloud seems to be playing havoc with the ozone over Boulder, Colo., according to ***Science News*** (Vol. 141, p. 14). The day a patch of Mt. Pinatubo's cloud passed overhead, balloon flights over Boulder measured the lowest December ozone values ever recorded at this site. David Hofmann of NASA in Boulder, said the low reading may in part reflect ozone destruction catalyzed by sulfuric acid particles in the cloud, and he predicts that when the cloud travels to the far south it may generate an "extra" ozone hole during the Antarctic fall. (The "usual" ozone hole appears during Antarctica's spring.)

⁂

A new research effort – the Task Force on Declining Amphibian Populations – has been established at Oregon State University in Corvallis, supported by the IUCN in collaboration with OSU's Center for Analysis of Environmental Change. James Vial, coordinator of the task force, says researchers around the world will document the extent of amphibian die-offs and study anything that might be causing it.

In Oregon's Cascade range, scientists have documented the unexplained die-off of millions of toad eggs in alpine lakes; the once common western spotted frog has become extinct in Western Oregon; in the Rocky Mountains, boreal toads that once clogged hiking trails are now scarce.

According to Professor Vial, the die-offs may be an early indicator of something seriously wrong in the global environment that later will affect a range of plant and animal life. "It's important," he said, "to determine whether it's a natural phenomenon or an indicator of some other environmental impact." Major research efforts underway include an $800,000 3-year study in Costa Rica and the $272,000 study at OSU.

⁂

"National Parks Fire Policy: Goals, Perceptions and Reality" is the title of a conference sponsored by Renewable Natural Resources Foundation and hosted by Utah State University's College of Natural Resources last Nov. 15-16 at Snowbird, Utah. Participants included NPS Associate Director for Natural Resources Eugene Hester, NPS Research Scientists David J. Parsons and Jan van Wagtendonk, Yellowstone NP Chief of Research John Varley, and former NPS Fire Ecologist James Agee. Parsons moderated Session I: Goals of the National Parks – a discussion of the need for increasing specificity of natural resource goals for NPs, and of the real and perceived conflicts involved in managing national parks – between scenic values and ecological goals, in maintaining natural values in light of increasing visitation, and when policy only partially allows natural processes to play a role.

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Given the long, checkered history of the search for sun-climate relations, many researchers will call it a statistical freak, but the "dazzling correlation" between solar activity and terrestrial temperature presented in the Nov. 1, 1991 issue of ***Science*** is "giving climatologists goose bumps." So says Richard Kerr in the magazines Research News section, commenting on the findings presented on pages 698-700 by Eigil Friis-Christensen and Knud Lassen of the Danish Meteorological Institute. The graphic representation shows two curves, tightly intertwined: one representing the interval between peaks in sunspot abundance, the other tracing the annual rises and falls of earth's average temperature.

Among the oft-fooled and thus wary body of climatologists, John Eddy of Boulder, Colo., and David Parker of England's Hadley Center for Climate Prediction and Research voiced a host of reservations, but admitted they were "mightily impressed" by the correlation coefficient of 0.95 – probably the highest ever found in this sort of work. The authors themselves suggest merely that variations in the solar cycle length appear to be "a possible indicator of long-term changes in the total energy output of the sun," and add:

"Estimation of the natural variability of the Earth's climate and its causes are needed before any firm conclusion regarding anthropogenic changes be made."

⁂

The potential magnitude of future vegetation change in Eastern North America is described by a paleontologist, a geographer and a geologist in ***Science*** Vol. 254:692-695 and their predictions could spell a vegetative nightmare for natural resource managers.

J.T. Overpeck, P.J. Bartlein, and T. Webb III provide a model-based assessment of how the natural vegetation of Eastern North America may change over the next 2 to 5 centuries in reponse to trace gas-induced climate change. They used pollen data and response surfaces to model the equilibrium response of vegetaton to the climate change simulated by atmospheric general circulation models (GCMs) and found that increases in atmospheric trace gas concentrations could warm the global average temperature 1.5 degrees to 4.5 degrees Centigrade by the end of the next century. Application of climate-pollen response surfaces to 3 climate model simulations of doubled preindustrial atmospheric $C^{O}2$ levels shows the change in the equilibrium distribution of natural vegetation over the next 200 to 500 years could be larger than the overall change during the past 7,000 to 10,000 yours and equivalent to the change that took place over the 1,000- to 3,000-year period of most rapid deglaciation. Some plant ranges and abundance maxima could shift as much as 500 to 1000 km in the next 200 to 500 years.

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The Florida DNR Newsletter, ***Resource Management Notes***, January 1992, contains (pp. 16-17) an item about Ant Surveys in Florida's State Parks, by Dr. Mark Deyrup of the Archbold Biological Station (813) 465-2571, excerpts from which are herewith reproduced.

"It is no news to Florida naturalists that the state is richly, even extravagantly, endowed with ants. With about 180 species, Florida is the ant capitol of the country ... Such a significant group deserves its own guidebook, and for the last 8 years I have been looking at ants throughout the state in preparation for a book on identification and natural history of Florida ants ...

"My last printout of state park ants, about a year old, contains about 500 entries from 30 state parks. Unfortunately, lists of ant species are not very informative to most people and I am trying to devise a system that will allow me to print up lists of species with a little information blurb on each species ... information on whether the species is native, its origin if exotic, its size, nest site, habitat, and any interactions with humans (normal humans, not ant people).

"A survey that shows that ants abound in Florida's state parks might appear to have been commissioned by the Florida Calamity Calendar or by some obscure religious sect that believes picnicking to be a sin. Even I find it difficult to imagine how an impressively long ant list for a particular park could be used in any positive publicity. The list could be accompanied by a statement that most of these ants are tiny, secretive, benign creatures that will never be seen by park visitors, but even this statement resembles damage control more than it does positive publicity.

"Eventually, of course, the public will come to the enlightened view that arthropod diversity is one of the most spectacular and fascinating features of the natural world. Pending that happy day, one may want to use the information with some caution. For example, one could lump the 68 ant species known from a park with the 19 butterfly species, and say 'There are 87 species of butterflies and other insects known from this park.' ... Perhaps Florida state parks have a role to play in ushering in the Age of Ant Appreciation."

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Perhaps even more distressing as environmental news than the decline of amphibians on the world scene is the catastrophic decline of mushroom populations throughout Europe. "Mass extinction" is the term used by John Jaenike, University of Rochester ecologist, who is concerned that fungi also may be vanishing from the United States.

The findings (or rather, the no-longer-findings) of Eef Arnolds – a fungal ecologist at the Agricultural University of the Netherlands, are described by Jeremy Cherfas on page 1458 of the Dec. 6, 1991 issue of ***Science***. The scale of loss is shown by comparing surveys carried out in the Netherlands between 1912 and 1954, when an average of 71 species of fungus was found per foray, with the period between 1973 and 1982, when a matched series of 15 surveys could turn up only 38 species per foray.

Both occurrence and size of mushrooms have plummeted. It took 50 times as many chanterelles to make up a kilogram in 1975 as it did in 1958. Arnolds rules out overpicking and forest management prac-

information crossfile

tices, because both edible and inedible mushrooms have declined and all types of mature forests show similar drops. The villain appears to be air pollution. Throughout Europe there is a negative correlation between abundance and diversity of fungi and levels of nitrogen, sulfur, and ozone in the air. The main offender appears to be farming.

The loss of a gourmet item of human food is not nearly so consequential as the loss of the network of fungal filaments that live in close symbiotic association with trees, providing water and minerals in exchange for carbohydrates. The resulting lowered resistance of trees to stress could lead to a mass dying of trees in time of severe frost or drought, Arnolds warns.

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From Wildlife Ecologist Doug Houston, at Olympic NP, comes an article by Paul Beier in the ***Wildlife Society Bulletin*** (19:403-412, 1991), titled "Cougar Attacks on Humans in the United States and Canada." The author attempted to document all attacks from Jan. 1, 1890 through Dec. 31, 1990 and describes his very conservative criteria for deciding whether the verified reports constituted "attacks" or "near-attacks." He documented 9 fatal attacks and 44 nonfatal attacks resulting in 10 human deaths and 48 nonfatal injuries. (The greater number of victims occurred because there were 2 victims in each of 5 attacks.) He deduced that cougar attacks "have clearly increased during the last 2 decades" and describes the victims (37 of 58 victims were children), their companions (or lack of), their positioning with regard to human habitation, and general deportment.

He describes behaviors that invite attack, behaviors that might prevent attack, and concludes that yearlings and underweight cougars are most likely to attack humans. Aggressive responses on the part of intended victims may avert an impending attack and repel attacks in progress, he found.

Houston notes that the article is "a good and timely summary" and adds that "we seem to be experiencing an increase in 'near-attacks' here at Olympic, but sample size is very small (thankfully)."

⁂

An article titled "Plight of the Plover" by Kathy Fackelmann, in the Dec. 7, 1991 issue of ***Science News***, describes the continuing stress under which the piping plovers (now on the threatened species list) must conduct their foraging and nesting practices. Both sanderlings and plovers are increasingly restricted in their foraging attempts by having to flee from humans – thus cutting their food intake. These birds cannot transfer their feeding to salt marshes or mud flats as many other shorebirds have done under human pressure. They have no alternative but to continue their efforts to feed in the same waves as recreational bathers and try to escape the plover predators who are attracted to plover habitat by human garbage left on the beaches. Fackelmann concludes the average citizen can have a big impact. "People can help protect the birds from predators by keeping beaches clean and pets leashed. And joggers, for their part, can maintain a respectful distance from these highly flappable foragers."

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The Dec. 6, 1991 ***Science*** "News and Comments" section carries a discussion of the worldwide impact of invasive exotic species, written by Elizabeth Culotta. The article is built around the October 1991 gathering sponsored by the Indiana Academy of Sciences to discuss "the homogenization of the world" and the biological threats thus imposed. The article describes the havoc wrought in manyh places in terms of lost crops and expensive control programs, and then discusses the "less visible ecological damage on a grand scale" that such invaders can inflict.

"When ecosystems are already under stress, as they now are in most parts of the world, a biological invader can deliver the coup de grace to native species by predation, competition, or by transforming landscapes," Culotta notes.

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A special issue of Water Resources Research on Western U.S. Alpine Watershed Studies (WRR 27:1537-1588, July 1991) contains 5 papers that discuss the Emerald Lake Watershed Study, an intensive site investigation of the biogeochemistry of a headwater system at 2800 m in Sequoia NP. Kathy Tonnessen of the Air Quality Division in Denver provides the introduction and discusses the cooperative program between NPS and the California Air Resources Board to determine impacts of acid deposition on watersheds and surface water quality. This study, conducted from 1983-1989, demonstrated the importance of snow chemistry and snow melt processes to the episodic acidification of dilute lakes and streams in the Sierra Nevada.

⁂

William Smith, Yale University, presents an excellent review of "Air Pollution and Forest Damage" in ***Chemical and Engineering News*** (69:30-43, Nov. 11, 1991). He recaps conclusions of the NAPA Program's conclusions regarding impacts of ozone and acid deposition on terrestrial ecosystems and then ranks regional air pollution stresses to vegetation as: ozone, heavy metals, and acid deposition. He stresses that the future of this research lies with long-term programs that document the health of forests and that attempt to distinguish negative effects of air pollution when compared to other natural (pests, disease) and anthropogenic stresses.

Fossil Butte To Host Paleontological Meeting

Fossil Butte National Monument will celebrate its 20th anniversary by hosting a 4-day Paleontological Resources Conference in September 1992 (specific dates to be determined). The conference will be directed toward managers, resource specialists, and interpreters, but will involve researchers as well. Paleontological resources are a relatively new issue within the NPS and periodic conferences have proven valuable to park managers and interpreters. BLM, USFS, and several Western state park managers also will be invited.

Major topics will cover development and encouragement of paleontological research on federal lands, interagency cooperative agreements, care and maintenance of paleontological collections, creative alternatives to interpreting fossil resources, recent developments in legislation dealing with such resources on federal lands, state permit systems, pertinent law enforcement issues, the challenge of exhibiting fossils in situ, and unique paleontological management programs at selected state parks.

If you have suggestions at this planning stage, the conference committee would like to hear from you. Questions, suggestions, and requests to be on our mailing list should go to Rachel Benton at Fossil Butte (307) 877-4455.

meetings of interest

1992

Apr. 23-24, MAPPING TOMORROW'S RESOURCES, A Symposium on the Uses of Remote Sensing Geographic Information Systems and Global Positioning Systems for Natural Resource Management, Utah State Univ., Logan, Utah. Contact: Dean's Office, Coll. of Nat. Res., Utah St. Univ., Logan, UT 84322-5200 (801) 750-2445.

May 4-6, THREATS TO THE NATIONAL WILDERNESS PRESERVATION SYSTEM: THE MANAGERIAL CHALLENGE, in Portland, OR; sponsored by NPS, USFS, BLM, and the Society of American Foresters Wilderness Subcommittee. Keynote speaker, Rupert Cutler; banquet speaker, Cong. Vento (D-MN). Contact: Alan Schmierer, NPS Western Regional Office, 600 Harrison St., Ste. 600, San Francisco, CA 94107; (415) 744-3959.

May 15-17, CRATER LAKE NP 90TH ANNIVERSARY SYMPOSIUM, Southern Oregon State Coll., Ashland, OR. Contact: Dr. Frank Lang, Dept. of Biology, Southern OR/State/Coll, Ashland, OR 97520 (503) 552-6342.

May 17-20, FOURTH NORTH AMERICAN SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT, in Madison, WI; more than 250 papers focusing on social biological aspects of natural resource and environmental issues, 4 plenary addresses, round tables, poster session, and field trips. Contact: Mary Miron, School of Nat Res, 1450 Linden Dr., Rm. 146, U/WI, Madison 53706; (608) 262-6968.

June 22-25, BIODIVERSITY TRAINING COURSE, location to be announced. See Mar. 9-12 notice above.

Aug. 3-7, MAPPING AND MONITORING GLOBAL CHANGE, is the theme of a 4-way Congress and Convention in Washington, DC., involving the Int'l Soc for Photogrammetry and Remote Sensing, the Amer. Soc. for Photogrammetry and Remote Sensing, the Amer. Cong. on Surveying and Mapping, and Resource Technology 92 (See GIS Notes, this issue, page 23).

Oct. 27-30, 19TH ANNUAL NATURAL AREAS CONFERENCE and 14TH ANNUAL MEETING OF THE NATURAL AREAS ASSN, at U/IN campus, Bloomington. Contact: Division of Nature Preserves, U/IN, 402 W. Washington St., Rm. W 267, Indianapolis 46204; (317) 232-4052.

Nov. 16-20, PARTNERS IN STEWARDSHIP, the George Wright Society Conference on Research and Resource Management in Natural and Cultural Parks and Reserves, Jacksonville, FL. Contacts: John Donahue, NPS, 18th & C Sts NW, Washington, DC 20240 (202) 208-4274 and Harry Butowsky, NPS, PO Box 37127, DC 20013-7127 (202) 343-8155.

Archeological Fieldwork At Yellowstone's Obsidian Cliff

By Leslie Davis, Stephen Aaberg, and Ann Johnson

Obsidian Cliff is only one of a number of potentially glassy rhyolite flows in and around Yellowstone NP, however prehistoric people selected that high quality obsidian source for tool making more often than any other Rocky Mountain source. Based on the chemical "fingerprinting" of archeological obsidian (primarily from sites outside the park), it is now known that early Native Americans were selecting and using Obsidian Cliff obsidian for making tools by at least 11,000 years ago. Intermittent use of obsidian quarried from Obsidian Cliff continued into the early historic period.

Obsidian Cliff is the name given one of four rhyolite lava flows north of the Yellowstone caldera. This topographic feature within the Rhyolite Plateau was formed 180,000 years ago by eruption through a vent 1 km to the east of where the highway between Norris and Mammoth passes Obsidian Cliff. That flow filled a preexisting valley and rapidly chilled against the old valley wall. Obsidian Creek downcut through the old valley wall and exposed the obsidian cliff. The top of the flow is covered by a loose rubble mantle resulting mostly from frost weathering of local bedrock. The presence of Paleozoic quartzite, Quaternary basalt, and igneous erratics suggests deposition by glacial transport and ice decay.

The NPS contracted with Montana State University in 1988 for technical data needed to develop a National Historic Landmark nomination for Obsidian Cliff. An archeological study was initiated because little was known regarding the spatial extent of quarry features, prehistoric obsidian procurement practices, and the within-source trace-element composition and geochemical variability of Obsidian Cliff obsidian.

Work was designed to provide evidence essential for understanding prehistoric quarrying activity and to analyze obsidian samples in order to fingerprint geochemically the Obsidian Cliff flow. Before fieldwork could begin, however, the Obsidian Cliff flow area was burned by the Wolf Creek fire of 1988. The survey was postponed and conducted during the 1989 field season. The burnoff of heavy vegetation cover created an additional research opportunity: to assess fire effects on prehistoric cultural features, artifacts, and geological obsidian.

As with most of the 1988 fires in Yellowstone NP, the Wolf Creek fire burned with varying intensity, differentially affecting specific geological and cultural landscapes. This mosaic burn pattern was evident over much of the Obsidian Cliff flow, approximately two-thirds of which was intensely burned.

The 1989 archeological study recorded 59 prehistoric obsidian procurement loci (discrete small-scale activity areas) within the exploited Obsidian Cliff flow. The plateau is considered to be a single, extensive lithic procurement site (48YE433). Surface and subsurface obsidian procurement loci (quarry features) are the most prominent archeological manifestations on the plateau. The quarry features vary in form and scale, ranging from single oval pits to multiple overlapping/interlocking pits that occupy large surface areas (up to 250 m long). Additionally, winding linear trenches and shallow quarries occur in surface obsidian outcrops. The general absence of occupation debris indicates that the prehistoric people who acquired obsidian moved to adjacent areas at lower elevations near water and shelter to establish camps and work the obsidian.

Intensely burned landscape *shown here reveals partially infilled, single oval pit – an obsidian quarry feature.*

Fire damage at Obsidian Cliff affected the physical environment and modified the archeological landscape (artifacts and context) at each of the 59 loci. Alteration was greatest at those loci that were burned intensely. The loci without vegetative cover were subject to erosion. Indeed, erosion already was evident (9 months post-fire) at some intensely burned areas where runoff had resulted in incipient gullying and mass wasting. Elk and deer had put deep tracks in the softened cultural surfaces at several sites, mixing cultural materials. While the adverse effects of such bioturbation (mixing) were minimal, they did impact cultural deposits deprived of protective duff and understory ground cover. Fortunately, potentially destructive on-the-ground fire suppression activity was not undertaken on the flow itself.

The major factor widely affecting both the physical and archeological environments was the windthrowing of burned trees. (These are not called deadfalls, since many are still living; they toppled because organics in the soil, which supported the roots and held trees upright, were eliminated by burning.) Windthrown trees often pulled up large quantities (up to several cubic meters) of sediment, rocks, and cultural materials trapped within the root masses. The disturbance and disruption of site stratigraphy and associated artifactual context were evident in many such instances.

Modification to surface obsidian artifacts at intensely burned loci was variable, but in certain cases, substantial. Archeological bone and organics on or close to the surface at intensely burned cultural loci would have been severely damaged or destroyed by fire, much as ungulate skeletal remains were burned. Exposed archeological and geological obsidian often was heat-fractured or exfoliated. Oxidized surfaces on a great number of obsidian artifacts at many burned loci were attributed to intense heating; oxidation appeared as a bright silver rind and a subtle dulling of rock surface.

Where obsidian was subjected to such heat, the internal structure commonly was modified. Such heating and oxidation of obsidian may prohibit, or complicate, the successful application of such technical studies as hydration dating and compositional analysis. The percentage of fire-fractured obsidian artifacts at most loci was low, but a large proportion of surface-exposed artifacts was oxidized.

Given the purposes of the 1989 archeological inventory and documentation project at Obsidian Cliff, the 1988 fire significantly enhanced both the long-range and short-range visibility of often subtle cultural features, loci, and artifacts. Pre-fire archeological reconnaissances of this heavily forested, dissected, high relief plateau had been severely hampered by accumulations of deadfall on steep slopes. Visibility through the forest itself was restricted to only a few meters by close-standing lodgepoles and a thick carpet of duff that masked the ground surface. The fire thus rendered visible a large number of archeological manifestations, exposing them to the possibility of vandalism.

In the last analysis, however, the 1988 fire and burnoff were opportune. The 1989 archeological reconnaissance, under post-fire conditions, provided basic primary data regarding quarry formation, lithic procurement strategies, and initial lithic reduction technology without the necessity of exposing artifacts, features, and activity areas by excavation.

The 1989 fieldwork yielded two major products: (1) the archeological inventory: (a) map of the Obsidian Cliff obsidian procurement site; (b) basic information regarding lithic extraction techniques employed by Native Americans; (c) a draft Obsidian Cliff National

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Fire History and Vegetation At Mesa Verde National Park

By Lisa Floyd-Hanna and Steve Budd-Jack

On July 8, 1989, a wildfire started on Long Mesa in Mesa Verde NP, and before the fire was controlled on July 27, it had burned 1,052 ha. As a result, several research agendas were pursued by the park staff and the Rocky Mountain Regional Office. Cultural resource personnel resurveyed the burn area, identified 9 new sites, and studied the effects of fire on surface and subsurface artifacts. Additional research began in 1991 to determine the past fire history of Mesa Verde NP and the pinon-juniper/shrub association. Following is a short update and review of that research, with special thanks to Dr. Will Romme of Fort Lewis College in assisting with project details and contributing to the methodology.

Mesa Verde NP is known for its extraordinary cultural resource, but it also occurs in a striking ecological setting. The mesa spans elevations of 1883 to 2612 m, and thus supports an array of vegetation types that include dominant pinon/juniper and Douglas fir stands. The role of fire in ecosystem patterning, both prior to and during the Anasazi occupation, is not known for this area of southwestern Colorado. The woodland, shrub, and forest types standing on the mesa today represent very different responses to fire. Ponderosa pine and Douglas fir may survive, and the shrub associations resprout vigorously after fire, their resprouting facilitated by frequent burning. Fire frequency and intensity have no doubt assisted in shaping the vegetation patterns found on Mesa Verde today. Such patterns are being used as keys to developing a fire history of the park.

In 1991, fire research focuses on two specific objectives. The first was to determine the vegetation patterns that have appeared since the 1989 fire on Long Mesa and in Long Canyon – a large fire impacted at least three different vegetation types; pinon/juniper woodland, shrub associations, and the Douglas fir/shrub association on the north escarpment. Three grid systems were established to sample vegetation that has resulted in each affected type.

The second objective for 1991 research was to develop a method for dating fires that occurred in the past. In southwest Colorado, Ponderosa pine (*Pinus ponderosse*) and Douglas fir (*Pseudotsuga menziesii*) are species that form fire scars and can be used to reconstruct fire history by traditional scar analysis. Unfortunately, very few trees of these species occur in Mesa Verda NP, and no fire scars have been located. The most abundant trees within the southern half of the mesa are pinon pine and Utah juniper, both of which are killed by fires.

We tested a method in which shrubs, which resprout vigorously after fire, were aged by annual ring counts to determine their time of origin. Dominant shrubs, Gambels oak (*Quercus gambelii*, Serviceberry (*Amelancheif utahensis*), Mountain mahogany (*Cercocarpus montanus*), and Fendlerbush (*Fendlera rubicola*), were sampled and aged in known historic fires (1934, 1959, 1972, and 1989). Although there is some variability within an individual as to the date of shoot emergence, we determined that by selecting the centermost shoot and restricting ourselves to the species *Quercus gambelii*, we are able to substantiate the known fire data within statistical reliability. *Fenlera rubicola* and *Cercocarpus montanus* also show promise for use in fire dating, but further analysis will be required to determine reliability of these dates.

During the 1991 field season, we will determine the stand origin dates of areas that are separated by clear discontinuities from adjacent vegetation. After incorporating the contribution of adaphic, exposure, or other factors, we will determine the date of potential fires resulting in each shrub community. The fire study will be closely tied to a vegetation community assessment, also to take place in 1992.

These two studies are complementary, since fire is a major shaper of vegetation patterning, and such patterning in turn influences fire behavior. Using aerial photos and other remotely sensed data, we will be preparing vegetation classification for filed verification in 1992. Methods used to ground truth the unsupervised classification of Landset imagery will be carried by the standard *releve* community analysis, similar to those being considered for general use in the Colorado Plateau national parks.

Dr. Floyd-Hanna is a biology professor at San Juan College in Farmington, NM and PI for two research projects at Mesa Verde; Budd-Jack is Resource Manager for Mesa Verda NP.

Obsidian Cliff

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Historic Landmark nomination; and (2) an extensive compilation or sourcebook of Obsidian Cliff flow geochemistries and comparable data for archeological obsidian specimens from interior western North America sources.

Obsidian Cliff flow geochemistry was characterized from 80 specimens analyzed by non-destructive x-ray fluorescence for zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). The resulting elemental homogeneity of specimens within that sample, collected from within the 14.5 k2 flow, was both remarkable and informative. These quantitative data are in excellent agreement with previously published geochemical standards for Obsidian Cliff obsidian. The variability of most source-diagnostic trace elements is limited; bivariate scatter diagrams cluster paired trace elements tightly.

This sample is the best source-specific, geochemical profile available for Obsidian Cliff. These data and others obtained from montane and plains archeological sites in Montana, and from other even more distant sites that contain Obsidian Cliff obsidian, are summarized in a technical report available from the Rocky Mountain Region: *The Obsidian Cliff National Historic Landmark Lithic Source Area, Yellowstone NP: Geoarchaeological Baselines and Perspectives*, by Leslie B. Davis, Stephen A. Aaberg, and James G. Schmitt (1991).

Davis is professor of anthropology at MT/State/U and curator of archaeology and anthropology with the Museum of the Rockies; Aaberg is a consulting archaeologist in Billings, MT; Johnson is a staff archeologist, Division of Cultural Resources, Rocky Mountain Region, NPS.

Integrated Approach To Virgin Islands Research

(Continued from page 1)

Institute of Tropical Forestry, has been studying forest dynamics in the Cinnamon Bay watershed since 1983. Other research projects on vegetation include those by Anne Reilly (New York Botanical Garden and University of Georgia), Dr. Becky Brown and Gary Ray (University of Wisconsin), and Gary Ray and Dr. Francisco Dallmeier (Smithsonian Institution). Dr. Pedro Acevedo is preparing a comprehensive, illustrated "Flora of St. John" with full descriptions of the vascular plants and information on distributions and local uses. The Soil Conservation Service (John Davis, Bruce DuBee) is providing complementary data on the physical and chemical nature of the island's soils. Soil characteristics are a key factor in determining vegetation patterns and the extent to which plant species native to St. John will thrive or exotics prevail. SCS will be characterizing the soils associated with some of the long-term vegetation plots established on the island.

As part of the NPS Coral Reef Assessment Program, park biologists are studying the coral reefs in Lameshur and Newfound Bays, and Dr. Jim Beets from the U.S.V.I. Division of Fish and Wildlife is monitoring reef fish populations in Lameshur and other bays. Dr. Lisa Muehlstein from the University of Richmond is conducting research on seagrass beds. Beginning in January 1988, the park's research staff has been collecting valuable baseline data on water quality at 29 sites around the island. Since 1987, Dr. Robert Askins and Dr. David Ewert have been censusing migratory and resident birds on the island.

Many of these studies incorporate data from before and after Hurricane Hugo and help elucidate the response of ecosystems to "disturbance". For those of us who went through Hugo, it seems a bit of an understatement to refer to this storm as a "disturbance". On Sept. 15, 1989, two days before Hurricane Hugo hit the USVI, it had a wind speed of 306 kmh at an altitude of 500 m and a surface wind of 259 kmh. Hugo was therefore a category 5 storm before it hit St. Croix, about 56 km south of St. John. An estimated maximum surface wind of 223 kmh was reported as the eye passed over St. Croix on the night of September 17 to 18. The eye of the storm had a forward speed of only 14 kmh when moving over St.Croix, and the hurricane battered the USVI for over 12 h.

While changing some peoples' lives forever, Hurricane Hugo did provide an opportunity to study the effect of a major disturbance on the island's forests and marine systems and recovery after the storm. The data which have been collected on the vegetation, coral reefs, reef fishes, and birds since the storm are especially valuable because they can be compared to pre-storm data from permanent study sites in the forest and on the reefs.

Research in the park is providing data that fill in gaps in our basic knowledge of the ecosystems of St. John but also have significance for other tropical sites (particularly other Caribbean islands) with similar resources. For example, the park has the largest remaining tract of tropical dry forest within a protected area in the Eastern Caribbean. Also, Virgin Islands National Park is one of the few areas in the Caribbean where forests that were cleared are being allowed to recover.

(Concluded on back cover)

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Little systematic information exists on soil moisture and temperature anywhere in the Caribbean. Recent research on the bird populations suggests that the island has some of the highest densities of migratory warblers in the Caribbean and a higher density of these songbirds than on the nearby island of St. Thomas which is highly developed and has little intact natural habitat. Askins et al. (1990) point out that "only a few long-term studies of birds have been accompanied by periodic analysis of vegetation in the study site". Data from the permanent vegetation plots are therefore enhancing the information on resident and migrant birds on St. John. Dr. Askins and Dr. Dave Ewert also are learning more about the relationship between forest area (size) and composition of bird communities. This work provides a basis for land-use decisions, showing the danger of fragmenting the forest and creating isolated patches of vegetation.

Botanical studies have shown that previous assumptions about elimination of plant species as a result of deforestation during the plantation era of the 1700s and 1800s are not valid. Current research suggests that few if any species were lost, but the relative abundance of native and introduced species has changed.

Throughout the Caribbean, degradation of marine systems is accompanying careless development of coastlines and upland areas. The Park Service is just beginning a cooperative study with the U.S.G.S. to compare sediment loads from one developed and one undeveloped watershed on St. John. Information on the erodibility of soils from the SCS study will also be useful for developing models of watershed processes.

While the primary objectives of the studies differ, together they represent an integrated approach to the management of natural resources in the biosphere reserve. There has been remarkably close cooperation and communication among the different investigators. The studies provide complementary data sets which allow the researchers to make better use of their own data and to extrapolate their findings to other sites in the Caribbean. The more we study St. John, the more we appreciate the value of Virgin Islands National Park and Biosphere Reserve. Though the park is small, the knowledge gained from its research program can contribute to our ability to protect marine and terrestrial resources in tropical environments.

Rogers is NPS Research Biologist at Virgin Islands NP.

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